Exhibit A

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/712,104	01/27/2009	7483998	ALC 3420	8217

76614 7590 01/07/2009

Kramer & Amado, P.C.
1725 Duke Street
Suite 240
Alexandria, VA 22314

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 866 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Peter Rabinovitch, Kanata, CANADA;

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

7590 09/25/2008

Law Office of Jim Zegeer
Suite 108
801 North Pitt Street
Alexandria, VA 22314

12/15/2008 HDESTA2 00000121 122325 10712104

01 FC:1501 1510.00 DA
02 FC:1504 300.00 DA

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of [redacted] Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

Patty Giebler (Depositor's name)
Patty Giebler (Signature)
12-15-08 (Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO
10/712,104	11/14/2003	Peter Rabinovitch	3465-Z	8217

TITLE OF INVENTION: SOFTWARE CONFIGURABLE CLUSTER-BASED ROUTER USING HETEROGENEOUS NODES AS CLUSTER NODES

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1440	$300	$0	$1740	12/26/2008

EXAMINER	ART UNIT	CLASS-SUBCLASS
POLLACK, MELVIN H	2145	709-238000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. Use of a Customer Number is required.

2. For printing on the patent front page, list
(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Alcatel Lucent
(B) RESIDENCE: (CITY and STATE OR COUNTRY): Paris, France

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☒ Issue Fee
☒ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): (Please first reapply any previously paid issue fee shown above)
☐ A check is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 12-2325 (enclose an extra copy of this form).

5. Change in Entry Status (from status indicated above)
☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature Patty Giebler Date 12-15-08
Typed or printed name Patty Giebler Registration No. _____

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

UNITED STATES PATENT AND TRADEMARK OFFICE

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United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
10/712,104	11/14/2003	Peter Rabinovitch	ALC 3420

CONFIRMATION NO. 8217

POA ACCEPTANCE LETTER

76614
Kramer & Amado, P.C.
1725 Duke Street
Suite 240
Alexandria, VA 22314

OC000000032842583

Date Mailed: 10/29/2008

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 10/23/2008.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/cbowen/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
10/712,104	11/14/2003	Peter Rabinovitch	3465-Z

CONFIRMATION NO. 8217

Law Office of Jim Zegeer
Suite 108
801 North Pitt Street
Alexandria, VA 22314

POWER OF ATTORNEY NOTICE

OC000000032842529

Date Mailed: 10/29/2008

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 10/23/2008.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

/cbowen/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
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Bib Data Sheet

CONFIRMATION NO. 8217

SERIAL NUMBER	FILING OR 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
10/712,104	11/14/2003 RULE	709	2145	ALC 3420

APPLICANTS

Peter Rabinovitch, Kanata, CANADA;

**** CONTINUING DATA ***************************

**** FOREIGN APPLICATIONS *********************

IF REQUIRED, FOREIGN FILING LICENSE GRANTED
** 02/23/2004

		STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed	☐ yes ☐ no	CANADA	8	36	3
35 USC 119 (a-d) conditions met	☐ yes ☐ no ☐ Met after Allowance				
Verified and Acknowledged	Examiner's Signature Initials				

ADDRESS
76614

TITLE
SOFTWARE CONFIGURABLE CLUSTER-BASED ROUTER USING HETEROGENEOUS NODES AS CLUSTER NODES

FILING FEE RECEIVED		
1058	FEES: Authority has been given in Paper No. _____ to charge/credit DEPOSIT ACCOUNT No. _____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

Print Form

PTO/SB/81 (07-08)
Approved for use through 12/31/2008. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

POWER OF ATTORNEY OR REVOCATION OF POWER OF ATTORNEY WITH A NEW POWER OF ATTORNEY AND CHANGE OF CORRESPONDENCE ADDRESS

Application Number	10/712,104
Filing Date	November 14, 2003
First Named Inventor	RABINOVITCH, P.
Title	SOFTWARE CONFIGURABLE CLUSTER-BASED ROUTER U[illegible]
Art Unit	2145
Examiner Name	M. H. Pollack
Attorney Docket Number	ALC 3420

I hereby revoke all previous powers of attorney given in the above-identified application.

☐ A Power of Attorney is submitted herewith.

OR

☒ I hereby appoint Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s) to prosecute the application identified above, and to transact all business in the United States Patent and Trademark Office connected therewith: 76614

OR

☐ I hereby appoint Practitioner(s) named below as my/our attorney(s) or agent(s) to prosecute the application identified above, and to transact all business in the United States Patent and Trademark Office connected therewith:

Practitioner(s) Name	Registration Number

Please recognize or change the correspondence address for the above-identified application to:

☒ The address associated with the above-mentioned Customer Number.

OR

☐ The address associated with Customer Number:

OR

☐ Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the:

☐ Applicant/Inventor.

OR

☒ Assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) (Form PTO/SB/96) submitted herewith or filed on _____.

SIGNATURE of Applicant or Assignee of Record

Signature	Gregory J. Murgia	Date	10/15/2008
Name	Gregory J. Murgia, Esq.	Telephone	+1 (908) 582-7109
Title and Company	Corporate Counsel, Authorized Representative of Alcatel		

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below*.

☒ *Total of 2 forms are submitted.

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/SB/96 (01-08)
Approved for use through 06/30/2008. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: ALCATEL

Application No./Patent No.: 10/712,104 Filed/Issue Date: November 14, 2003

Entitled: SOFTWARE CONFIGURABLE CLUSTER-BASED ROUTER USING HETEROGENEOUS NODES AS CLUSTER NODES

ALCATEL, a Corporation
(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that it is:

1. ☑ the assignee of the entire right, title, and interest; or

2. ☐ an assignee of less than the entire right, title and interest
(The extent (by percentage) of its ownership interest is_____ %)

in the patent application/patent identified above by virtue of either:

A. ☑ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 014700, Frame 0582, or for which a copy thereof is attached.

OR

B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

3. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet.

☐ As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (*i.e.*, a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

Gregory J. Murgia — Signature
10/15/2008 — Date
Gregory J. Murgia — Printed or Typed Name
908 582-7109 — Telephone Number
Corporate Counsel, Authorized Representative of Alcatel — Title

Electronic Acknowledgement Receipt

EFS ID:	4166423
Application Number:	10712104
International Application Number:	
Confirmation Number:	8217
Title of Invention:	SOFTWARE CONFIGURABLE CLUSTER-BASED ROUTER USING HETEROGENEOUS NODES AS CLUSTER NODES
First Named Inventor/Applicant Name:	Peter Rabinovitch
Correspondence Address:	Law Office of Jim Zegeer - Suite 108 801 North Pitt Street Alexandria VA 22314 US 7036848333 -
Filer:	Terry Wayne Kramer/Wanda Ricks
Filer Authorized By:	Terry Wayne Kramer
Attorney Docket Number:	3465-Z
Receipt Date:	23-OCT-2008
Filing Date:	14-NOV-2003
Time Stamp:	16:27:33
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		ALC3420POA.pdf	1738998 b6b9741094366bd65dedf1c8b99dc4c61e211fe7	yes	2

	Multipart Description/PDF files in .zip description		
	Document Description	Start	End
	Power of Attorney	1	1
	Assignee showing of ownership per 37 CFR 3.73(b).	2	2

Warnings:	
Information:	
Total Files Size (in bytes):	1738998

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

7590 09/25/2008

Law Office of Jim Zegeer
Suite 108
801 North Pitt Street
Alexandria, VA 22314

EXAMINER	
POLLACK, MELVIN H	
ART UNIT	PAPER NUMBER
2145	

DATE MAILED: 09/25/2008

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/712,104	11/14/2003	Peter Rabinovitch	3465-Z	8217

TITLE OF INVENTION: SOFTWARE CONFIGURABLE CLUSTER-BASED ROUTER USING HETEROGENEOUS NODES AS CLUSTER NODES

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1440	$300	$0	$1740	12/26/2008

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL-85 (Rev. 08/07) Approved for use through 08/31/2010.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

7590 09/25/2008

Law Office of Jim Zegeer
Suite 108
801 North Pitt Street
Alexandria, VA 22314

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/712,104	11/14/2003	Peter Rabinovitch	3465-Z	8217

TITLE OF INVENTION: SOFTWARE CONFIGURABLE CLUSTER-BASED ROUTER USING HETEROGENEOUS NODES AS CLUSTER NODES

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1440	$300	$0	$1740	12/26/2008

EXAMINER	ART UNIT	CLASS-SUBCLASS
POLLACK, MELVIN H	2145	709-238000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____

2 _____

3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:

❑ Issue Fee

❑ Publication Fee (No small entity discount permitted)

❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

❑ A check is enclosed.

❑ Payment by credit card. Form PTO-2038 is attached.

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/712,104	11/14/2003	Peter Rabinovitch	3465-Z	8217

7590 09/25/2008

Law Office of Jim Zegeer
Suite 108
801 North Pitt Street
Alexandria, VA 22314

EXAMINER	
POLLACK, MELVIN H	
ART UNIT	PAPER NUMBER
2145	

DATE MAILED: 09/25/2008

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 866 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 866 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

Notice of Allowability	Application No. 10/712,104	Applicant(s) RABINOVITCH, PETER	
	Examiner MELVIN H. POLLACK	Art Unit 2145	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *the RCE and amendment dated 08 July 2008*.

2. ☒ The allowed claim(s) is/are *1-19,21-26 and 28-36*.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☒ Other *see attached office action*.

/M. H. P./ Examiner, Art Unit 2145	/Jason D Cardone/ Supervisory Patent Examiner, Art Unit 2145

DETAILED ACTION

Allowable Subject Matter

1. Claims 1-19, 21-26, and 28-36 are allowed.

2. The following is an examiner's statement of reasons for allowance: the examiner agrees with the applicant in regards to the novelty of the new claims.

3. Applicant has amended the independent claims (P. 10) and further defined many of the limitations (P. 11), along with further providing motivations for the structure and differentiations from Syvanne (Pp. 12-13).

4. The claims 17 and 26 are drawn towards the creation of router cluster nodes and their interconnections (internal and external links), such that they are configured to exchange packets. In particular, the usage of external links and scalable routers is novel and non-obvious. In addition, claim 1 includes other features such as the use of special purpose nodes.

5. All other claims are dependent from an allowable claim.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

6. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. They regard further background teachings on the case.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MELVIN H. POLLACK whose telephone number is (571)272-3887. The examiner can normally be reached on 8:00-4:30 M-F.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jason Cardone can be reached on (571) 272-3933. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/M. H. P./
Examiner, Art Unit 2145
16 September 2008

/Jason D Cardone/
Supervisory Patent Examiner, Art Unit 2145

Notice of References Cited	Application/Control No. 10/712,104	Applicant(s)/Patent Under Reexamination RABINOVITCH, PETER	
	Examiner MELVIN H. POLLACK	Art Unit 2145	Page 1 of 4

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-6,996,631	02-2006	Aiken et al.	709/242
*	B	US-6,954,784	10-2005	Aiken et al.	709/220
*	C	US-7,353,276	04-2008	Bain et al.	709/225
*	D	US-7,353,259	04-2008	Bakke et al.	709/208
*	E	US-7,039,784	05-2006	Chen et al.	711/170
*	F	US-2005/0018665	01-2005	Jordan et al.	370/388
*	G	US-7,421,478	09-2008	Muchow, James D.	709/209
*	H	US-2005/0091396	04-2005	Nilakantan et al.	709/232
*	I	US-2003/0154306	08-2003	Perry, Stephen Hastings	709/245
*	J	US-7,028,183	04-2006	Simon et al.	713/168
*	K	US-6,965,936	11-2005	Wipfel et al.	709/224
*	L	US-2001/0052024	12-2001	DEVARAKONDA et al.	709/238
*	M	US-2003/0018927	01-2003	Gadir et al.	714/4

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Baker, F. "Requirements for IP Version 4 Routers," RFC 1812, June 1995, Pp. 1-175.
	V	Varadhan, K. "BGP OSPF Interaction," RFC 1364, September 1992, Pp. 1-14.
	W	Li, T. et al. "Cisco Hot Standby Router Protocol (HSRP)," RFC 2281, March 1998, Pp. 1-17.
	X	Knight, S. et al. "Virtual Router Redundancy Protocol," RFC 2338, April 1998, Pp. 1-27.

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Notice of References Cited	Application/Control No. 10/712,104	Applicant(s)/Patent Under Reexamination RABINOVITCH, PETER	
	Examiner MELVIN H. POLLACK	Art Unit 2145	Page 2 of 4

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2003/0237016	12-2003	Johnson et al.	714/4
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

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	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Welling, Girish et al. "CLARA: A CLuster-based Active Router Architecture," IEEE MICRO, 2001, Pp. 1-8.
	V	Guo, Jiani et al. "A Cluster-Based Active Router Architecture SUpporting Video/Audio Stream Transcoding Service," Proceedings of the International Parallel and Distributed Processing Symposium, 26 April 2003, Pp. 1-8.
	W	Chiueh, Tzi-cker and Pradhan, Prashant. "High Performance IP Routing Table Lookup Using CPU Caching," IEEE INFOCOM, 1999, Pp. 1-8.
	X	Chiueh, Tzi-cker and Pradhan, Prashant. "Suez: A Cluster-Based Scalable Real-Time Packet Router," Proceedings of the 20th International Conference on Distributed Computing Systems, 13 April 2000, Pp. 136-144.

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Notice of References Cited	Application/Control No. 10/712,104	Applicant(s)/Patent Under Reexamination RABINOVITCH, PETER	
	Examiner MELVIN H. POLLACK	Art Unit 2145	Page 3 of 4

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-			
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

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	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Aversa, L. and Bestavros, A. "Load Balancing a Cluster of Web Servers: Using Distributed Packet Rewriting," IEEE International Performance, Computing, and Communications Conference (IPCCC), 22 February 2000, Pp. 24-29.
	V	Wolf, T. and Turner, J.S. "Design Issues for High-Performance Active Routers," IEEE Journal on Selected Areas in Communications, Vol. 19, Issue 3, March 2001, Pp. 404-409.
	W	Pappu, Prashanth et al. "Distributed Queueing in Scalable High Performance Routers," 22nd Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM), Volume 3, 3 April 2003, Pp. 1633-1642.
	X	Vuppala, Vibhavasu and Ni, Lionel M. "Design of a Scalable IP Router," IEEE Hot Interconnects, 22 July 1997, Pp. 1-7.

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Notice of References Cited	Application/Control No. 10/712,104	Applicant(s)/Patent Under Reexamination RABINOVITCH, PETER	
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U.S. PATENT DOCUMENTS

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FOREIGN PATENT DOCUMENTS

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	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Keshav, S. and Sharma, R. "Issues and Trends in Router Design," IEEE Communications Magazine, Volume 36, Issue 5, May 1998, Pp. 144-151.
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10712104	RABINOVITCH, PETER
	Examiner	Art Unit
	MELVIN H POLLACK	2145

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	03/17/2008	09/16/2008							
1	1	✓	=							
2	2	✓	=							
3	3	✓	=							
4	4	✓	=							
5	5	✓	=							
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33	35	✓	=							
34	36	✓	=							

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10712104	RABINOVITCH, PETER
	Examiner	Art Unit
	MELVIN H POLLACK	2145

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

Issue Classification

Application/Control No.	Applicant(s)/Patent Under Reexamination
10712104	RABINOVITCH, PETER
Examiner	**Art Unit**
MELVIN H POLLACK	2145

ORIGINAL

CLASS	SUBCLASS
709	238

CROSS REFERENCE(S)

CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
709	232	233	241		
714	4				
370	218	230	238	244	
370	389				

INTERNATIONAL CLASSIFICATION

CLAIMED					NON-CLAIMED				
G	0	6	F	15 / 173 (2006.0)	G	0	6	F	15 / 177 (2006.0)
G	0	6	F	15 / 16 (2006.0)	G	0	6	F	9 / 00 (2006.0)
G	0	6	F	11 / 00 (2006.0)	G	0	6	F	9 / 24 (2006.0)
H	0	4	J	1 / 16 (2006.0)	G	0	6	F	1 / 24 (2006.0)
H	0	4	J	3 / 14 (2006.0)	G	0	1	R	31 / 08 (2006.0)
H	0	4	L	12 / 26 (2006.0)	G	0	8	C	15 / 00 (2006.0)
H	0	4	L	12 / 28 (2006.0)	H	0	4	L	1 / 00 (2006.0)
H	0	4	L	12 / 56 (2006.0)					

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	17	17	31	33										
2	2	18	18	32	34										
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13	13	27	29												
14	14	28	30												
15	15	29	31												
16	16	30	32												

/MELVIN H POLLACK/ Examiner.Art Unit 2145	09/16/08	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	34	
/JASON D CARDONE/ Supervisory Patent Examiner.Art Unit 2145	09/23/2008	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	4A

U.S. Patent and Trademark Office

Part of Paper No. 20080916

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10712104	RABINOVITCH, PETER
	Examiner	Art Unit
	MELVIN H POLLACK	2145

SEARCHED			
Class	Subclass	Date	Examiner
above	update	9/17/08	MHP

SEARCH NOTES		
Search Notes	Date	Examiner
EAST - Search Notes Addendum	9/17/08	MHP
NPL - RFC Search: router, cluster, external link, special router, scalable router, router node		
NPL - Google Scholar: cluster based router, special purpose router cluster node, scalable router external link		

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner
PGPub	Search	9/17/08	MHP

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	4691	cluster near2 (router or node)	US-PGPUB; USPAT; USOCR	OR	ON	2008/09/17 12:55
L2	2639	L1 and @ad<="20031114"	US-PGPUB; USPAT; USOCR	OR	ON	2008/09/17 12:55
L3	86766	special adj purpose	US-PGPUB; USPAT; USOCR	OR	ON	2008/09/17 12:55
L4	312	L2 and L3	US-PGPUB; USPAT; USOCR	OR	ON	2008/09/17 12:55
L5	1356841	scale or scalable	US-PGPUB; USPAT; USOCR	OR	ON	2008/09/17 12:56
L6	1257	L2 and L5	US-PGPUB; USPAT; USOCR	OR	ON	2008/09/17 12:56
L7	211	L4 and L6	US-PGPUB; USPAT; USOCR	OR	ON	2008/09/17 12:56
L8	48	L7 and ((link or network) near2 (external or internal))	US-PGPUB; USPAT; USOCR	OR	ON	2008/09/17 12:56
L9	3443	(709/232 or 709/233 or 709/235 or 709/238 or 709/239 or 709/241 or 714/4 or 370/218 or 370/230 or 370/230.1 or 370/238 or 370/244 or 370/389).ccls. and @ad<="20031114"	US-PGPUB	OR	ON	2008/09/17 13:12
L10	86	L9 and cluster.clm.	US-PGPUB	OR	ON	2008/09/17 13:14
L11	515	L9 and router.clm.	US-PGPUB	OR	ON	2008/09/17 13:14
L12	14	L10 and L11	US-PGPUB	OR	ON	2008/09/17 13:14

9/17/08 1:27:54 PM
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1PW RCE $

REQUEST FOR CONTINUED EXAMINATION (RCE) TRANSMITTAL

Subsection (b) of 35 U.S.C. §132, effective on May 29, 2000, provides for continued examination of an utility or plant application filed on or after June 8, 1995.
See The American Inventors Protection Act of 1999 (AIPA).

Application Number	10/712,104
Filing Date*	November 14, 2003
First Named Inventor	P. Rabinovitch
Group Art Unit	2145
Examiner Name	M. Pollack
Attorney Docket No.	RABI3002/BEU

This is a Request for Continued Examination (RCE) under 37 C.F.R. §1.114 of the above-identified application.
NOTE: * Filing date must be on or after June 8, 1995; but if before May 29, 2000, then consider a CPA.

1. Please consider the following as the required submission under 37 C.F.R. §1.114:
   - ☒ a. **The Amendment/Reply filed on (date): July 7, 2008**
   - ☐ b. The Information Disclosure Statement (IDS) filed on (date):
   - ☐ c. The arguments in the Brief/Reply Brief filed on (date):
   - ☐ d. The ___ page(s) of Form PTO-1449 and copy of each listed document filed (date):
   - ☐ e. Other:
2. ☒ **A one- month Petition for Extension of Time is filed herewith.**
3. ☐ The Commissioner is authorized to credit any overpayment and charge any deficiency in any fees required under 37 CFR 1.16 and/or 1.17 to Deposit Account No. 02-0200.
4. ☒ **A check in the amount of $120 is submitted herewith.**
5. ☐ This Request is transmitted by facsimile to number (703) _____.
6. ☐ Other:

THE RCE FEE IS CALCULATED AS FOLLOWS:						Basic Fee:	$810.00
Total Claims:		-		(highest number previously paid for) =		X $50 =	
Independent Claims:		-		(highest number previously paid for) =		X $200 =	
Correspondence Address: 23364 Customer Number						Multiple Dependent Claim (add $360.00):	
						Subtotal:	$810.00
						50% Reduction if Small Entity Status:	
Phone: 703-683-0500 Fax: 703-683-1080						Total:	$810.00

Date:	Name:	Signature:	Reg. No.
July 8, 2008	Benjamin E. Urcia		33,805

RCE -12-9-04.wpd (09Dec04)

07/09/2008 SZEWDIE1 00000045 10712104
01 FC:1801 810.00 OP

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

IN RE APPLICATION OF: PETER RABINOVITCH
SERIAL NO.: 10/712,104
FILED: November 14, 2003
FOR: SOFTWARE CONFIGURABLE CLUSTER-BASED ROUTER USING HETEROGENOUS NODES AS CLUSTER NODES

GROUP ART UNIT: 2145
EXAMINER: M. Pollack
ATTY. REFERENCE: RABI3002/BEU

PETITION FOR EXTENSION OF TIME

COMMISSIONER OF PATENTS
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Applicant requests that the time for taking action in this case be extended pursuant to *37 CFR 1.136 (a)* for:

☒ One Month ☐ Three Months
☐ Two Months ☐ Four Months
☐ Five Months

The fee set in *37 CFR 1.17* for the extension of time is **$120.00**.

☒ Fee enclosed. Please charge any additional fee required for this extension of time to **Deposit Account Number 02-0200**. A duplicate copy of this paper is enclosed.

☐ Charge fee to **Deposit Account Number 02-0200**. A duplicate copy of this paper is enclosed.

☐ Applicant is a **small entity** entitled to pay reduced fees in this application.
A verified small entity statement ☐ has been filed. ☐ is enclosed.

Also enclosed is a:

☐ Response ☐ Notice of Appeal ☐ Appeal Brief

☒ **Request for Continued Examination (RCE)**

23364
Customer Number
Phone: (703) 683-0500

DATE: July 8, 2008

Respectfully submitted,

Benjamin E. Urcia
Attorney for Applicant
Registration Number: 33,805

07/09/2008 SZEWDIE1 00000045 10712104
02 FC:1251 120.00 OP

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
10/712,104	11/14/2003	

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)	SMALL ENTITY ☐		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	07/08/2008	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 34	Minus	** 36	= 0	X $ =		OR	X $50=	0
	Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $ =		OR	X $210=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/ROSS W. BROWN/

FILED BY FACSIMILE–FAX NO. 571-273-8300–SEVENTEEN (17) PAGES

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

IN RE APPLICATION OF: PETER RABINOVITCH
SERIAL NO.: 10/712,104
FILED: November 14, 2003
FOR: SOFTWARE CONFIGURABLE CLUSTER-BASED ROUTER USING HETEROGENEOUS NODES AS CLUSTER NODES

GROUP ART UNIT: 2145
EXAMINER: M. Pollack
ATTY. REFERENCE: RABI3002/BEU

COMMISSIONER OF PATENTS
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Transmitted herewith is a communication/amendment in the above-identified application.

☐ Small entity status under *37 CFR 1.9* and *1.27* is claimed.

☒ No additional fee is required.

The fee, if any, has been calculated as shown below:

Fee Basis	Number of Claims After Amendment	Highest Number Previously Paid For	Extra Claims	Small Entity	Full Fee
Total Claims		- [1]	= [3]	× $ 25 =	× $ 50 =
Independent Claims		- [2]	= [3]	× $100 =	× $ 200 =
☐ First Presentation of Proper Multiple Dependent Claim				+ $180 =	+ $360 =
			TOTAL		

[1] If less than 20 enter 20. [2] If less than 3 enter 3. [3] If less than 0 enter 0.

☐ Please charge my **Deposit Account Number 02-0200** in the amount of $_____. A duplicate copy of this sheet is attached.

☐ A check in the amount of $_____ is attached.

☐ The Commissioner is hereby authorized to charge any additional fees associated with this communication, including fees due under *37 CFR 1.16* and *37 CFR 1.17* or credit any overpayment to **Deposit Account Number 02-0200**. A duplicate copy of this sheet is attached.

☐ Also enclosed is/are:

I HEREBY CERTIFY THAT THIS PAPER IS BEING FACSIMILE TRANSMITTED TO THE U.S. P.T.O. ON THE DATE SHOWN BELOW.
(PRINT) J. Holmes
(SIGN) J Holmes
(DATE) 7-7-08

23364
Customer Number
Phone: (703) 683-0500

DATE: July 7, 2008

Respectfully submitted,

Benjamin E. Urcia
Attorney for Applicant
Registration Number: 33,805

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re U.S. Patent Application of:	)	**Group Art Unit: 2145**
	)	
Peter RABINOVITCH	)	**Examiner: M. Pollack**
	)	
Serial Number: 10/712,104	)	***Attorney Docket*: RABI3002/BEU**
	)	
Filed: November 14, 2003	)	**Confirmation No.: 8217**

For: Software Configurable Cluster-Based Router Using Heterogeneous Nodes as Cluster Nodes

AMENDMENT AND RESPONSE

Honorable Commissioner For Patents
P.O. Box 1450
Alexandria, VA. 22313-1450

Sir:

This paper is in response to the Official Action dated April 7, 2008.

Amendments to the claims begin on page 2.

Remarks/Arguments begin on page 10.

AMENDMENTS TO CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (CURRENTLY AMENDED) A cluster-based router comprising:
   a. a plurality of interconnected router cluster nodes, the routing capacity of the cluster router increasing substantially O(N) with the number N of router cluster nodes in the cluster router, each router cluster node having a group of cluster router external links enabling packet exchange with a plurality of external communication network nodes, wherein said plurality of interconnected router cluster nodes appears to external communications networks and nodes as a single communications network attached router;
   b. at least one special purpose cluster node providing special packet processing functionality that is not provided by any other of said router cluster nodes in the cluster router, wherein said at least one special purpose cluster is interconnected in a lattice of the cluster router but cannot be counted on to perform routing functions performed by said others of said router cluster nodes;
   c. a plurality of cluster router internal links interconnecting cluster nodes forming an intra-connection network ensuring a high path diversity in providing resiliency to failures; and
   d. a provisioned router-cluster-node-centric configuration distributed to each router cluster node for operating in accordance therewith in effecting distributed routing of the conveyed packets, wherein said provisioned router-cluster-node-centric configuration takes into account that said at least one special purpose router cluster node cannot be counted on to be aware of, or be configured via, said distributed cluster-node-centric router cluster node configuration[[,]]

~~employing the at least one special purpose router cluster node to provide a reduction in the development, validation, deployment and reconfiguration of the cluster router~~.

2. (ORIGINAL) The cluster router claimed in claim 1, wherein the router-cluster-node-centric configuration further comprises routing functional blocks and specifies packet processing flows between the routing functional blocks effecting packet processing employing one of: a single router cluster node, and a group of cluster nodes.

3. (ORIGINAL) The cluster router claimed in claim 1, wherein each router cluster node further comprises a personal computer platform providing flexibility and cost savings in the development, deployment, maintenance, and expandability of the cluster router.

4. (ORIGINAL) The cluster router claimed in claim 1, wherein at least one special purpose cluster node providing special packet processing functionality further comprises one of: a specially coded personal computer platform, a personal computer platform having designed hardware characteristics in providing specific functionality/ dedicated hardware implemented equipment designed to provide an enhancement in providing special packet processing functionality/ and a router cluster node further coded to provide special packet processing functionality.

5. (ORIGINAL) The cluster router claimed in claim 1, wherein the intra-connection network further comprises an n dimensional toroidal topology, wherein 2*n internal links interconnect each router cluster node with 2*n adjacent neighboring router cluster nodes; the routing capacity of the cluster router being increased substantially linearly by adding an n-1 dimensional slice of router cluster nodes to the cluster router.

6. (ORIGINAL) The cluster router claimed in claim 5, wherein the intra-connection network comprises a three dimensional toroidal topology, wherein six internal links interconnect each router cluster node with six adjacent neighboring router cluster nodes.

7. (ORIGINAL) The cluster router claimed in claim 1, wherein the intra-connection network further comprises one of unidirectional and bi-directional internal interconnecting links.

8. (ORIGINAL) The cluster router claimed in claim 1, further comprising: a router cluster node designated as a management node, should a management node designated router cluster node fail, another router cluster node being designated as a management node without making changes to the cluster router infrastructure.

9. (ORIGINAL) The cluster router claimed in claim 1, further comprising: a router cluster node designated as a special purpose cluster node, should a special purpose cluster node designated router cluster node fail, another router cluster node being designated as a special purpose cluster node without making changes to the cluster router infrastructure.

10. (ORIGINAL) The cluster router claimed in claim 1, further comprising:

a. at least one management node; and

b. a plurality of management links interconnecting the at least one management node with the plurality of router cluster nodes and enabling one of out-of-band: configuration deployment to each router cluster node, router cluster node initialization, and reporting functionality,

employing the plurality of management links reducing an in-band cluster router management overhead.

11. (ORIGINAL) The cluster router claimed in claim 10, wherein the plurality of management links from one of a star and a bus topology.

12. (ORIGINAL) The cluster router claimed in claim 11, wherein the at least one special purpose cluster node is associated with the management node, special functionality being available one-hop-away from each router cluster node.

13. (ORIGINAL) The cluster router claimed in claim 1, further comprising an cluster router internal addressing process dynamically determining router cluster node addressing.

14. (ORIGINAL) The cluster router claimed in claim 1, further comprising a cluster router external addressing process dynamically determining a cluster router address.

15. (ORIGINAL) The cluster router claimed in claim 1, further comprising means for distributing to each router cluster node information regarding availability and addressing information regarding special purpose cluster nodes.

16. (ORIGINAL) The cluster router claimed in claim 15, further employing methods of detecting special purpose cluster nodes providing special packet processing functionality.

17. (CURRENTLY AMENDED) A router cluster node of a plurality of router cluster nodes interconnected in a cluster router, each router cluster node comprising:

a. a plurality of cluster router internal interconnecting links connected thereto, the internal interconnecting links enabling the exchange of packets with adjacent cluster nodes in the cluster router;

b. at least one cluster router external link connected ~~thereto~~ to each of the cluster router nodes interconnected in the cluster router, the at least one external link enabling exchange of packets between ~~external~~ communications network nodes external to said cluster router and the cluster router;

c. a router-cluster-node-centric configuration to effect distributed routing of the conveyed packets, and

~~wherein each router cluster node comprises a personal computer platform providing flexibility and cost savings in the development, deployment, maintenance, and expandability of the cluster router;~~

wherein the ~~equivalency between~~ inclusion of said at least one external link in each of the router cluster nodes in the cluster router ~~providing~~ provides a scalable router.

18. (ORIGINAL) The router cluster node claimed in claim 17, wherein the router-cluster-node-centric configuration further comprises routing functional blocks and specifies packet processing flows between the routing functional blocks effecting packet routing employing one of: a single router cluster node, and a group of router cluster nodes.

19. (ORIGINAL) The router cluster node claimed in claim 18, wherein the router-cluster-node-centric configuration further comprises routing functional blocks determining a need for special packet processing and specifies packet processing flows forwarding packets to at least one special purpose cluster node associated with the router cluster.

Claim 20. (CANCELLED)

21. (ORIGINAL) The router cluster node claimed in claim 17, wherein 2*n cluster router internal links interconnect the router cluster node with 2*n adjacent neighboring router cluster nodes in accordance with an n dimensional toroidal topology, the routing capacity of the cluster router being increased substantially linearly by adding an n-1 dimensional slice of router cluster nodes to the cluster router.

22. (ORIGINAL) The router cluster node claimed in claim 17, further comprising: a management link interconnecting the router cluster node to a management node.

23. (ORIGINAL) The router cluster node claimed in claim 17, further providing management functionality.

24. (ORIGINAL) The router cluster node claimed in claim 17, further providing special packet processing functionality as a special purpose cluster node.

25. (ORIGINAL) The router cluster node claimed in claim 24, wherein the special purpose cluster node provides packet processing in respect one of: authentication, decryption, encryption, decoding, encoding, billing, directory access, and video stream processing.

26. (CURRENTLY AMENDED) A router-cluster-node-centric configuration enabling the provision of a distributed packet routing response in a cluster router having a plurality of router cluster nodes, each including at least one external link enabling packet exchange with communication network nodes external to said cluster router, the configuration comprising:

a. a plurality of routing functional blocks; [[and]]

b. at least one router-cluster-node-centric packet processing flow, via the plurality of routing functional blocks, to effect routing of packets received at the cluster router employing one of a single router cluster node and a group of router cluster nodes;

c. an entry-and-routing processing packet processing flow specification;

d. a transit packet processing flow specification; and

e. an exit packet processing packet processing flow specification,

the packet processing flow specifications enabling a received packet to undergo entry and routing processing at an entry router cluster node, optionally transit via at least one intermediary router cluster node, and undergo exit processing at an exit router cluster node.

Claim 27. (CANCELLED)

28. (ORIGINAL) The router-cluster-node-centric configuration claimed in claim 26, wherein the router cluster node configuration further employs a tag conveyed with each packet within the cluster router infrastructure, the tag holding specifiers for tracking packet processing within the cluster router.

29. (ORIGINAL) The router-cluster-node-centric configuration claimed in claim 28, wherein each tag identifies an associated packet as one having received a routing response and propagating through the cluster router towards a specified exit router cluster node.

30. (ORIGINAL) The router-cluster-node-centric configuration claimed in claim 28, wherein each tag identifies an associated packet as one requiring special processing and propagating through the cluster router towards one of: a special purpose cluster node, and the router cluster node which determined that the packet required special processing.

31. (ORIGINAL) The router-cluster-node-centric configuration claimed in claim 28, wherein each tag comprises a combination of: an optional packet header, a packet trailer, and an additional header encapsulating the associated packet having cluster router relevance only.

32. (ORIGINAL) The router-cluster-node-centric configuration claimed in claim 28, wherein each tag holds a tag time-to-live specification decremented while the associated packet propagates via router cluster nodes in the cluster, the packet being discarded when the time-to-live specification is zero and the packet has not reached a corresponding exit router cluster node thereby reducing transport overheads.

33. (ORIGINAL) A router-cluster-node-centric configuration enabling the provision of a distributed packet routing response in a cluster router having a plurality of router cluster nodes and at least one special purpose cluster node as claimed in claim 26, the configuration further comprising:

a. at least one routing functional block determining a need for special functionality in respect of processing a packet; and

b. at least one router-cluster-node-centric packet processing flow effecting forwarding of the packet to a special purpose cluster node for processing.

34. (ORIGINAL) The router-cluster-node-centric configuration claimed in claim 33, wherein the at least one router-cluster-node-centric packet processing flow further specifies one of: storing a copy of the packet header and a corresponding tag in an optional header of the packet; and storing information about the packet in a storage structure for the purposes of continuing packet processing in accordance with the router-cluster-node-centric configuration.

35. (ORIGINAL) The router-cluster-node-centric configuration claimed in claim 33, wherein the at least one cluster-node-centric packet processing flow further specifies at least one packet processing flow for further processing a packet having undergone packet processing at a special purpose cluster node.

36. (ORIGINAL) The router-cluster-node-centric configuration claimed in claim 33, wherein the at least one cluster-node-centric packet processing flow further specifies employing addressing information stored in the packet header in forwarding the packet requiring special processing towards a special purpose cluster node.

REMARKS

Reconsideration of the application is respectfully requested for the following reasons:

1. Amendments to Claims

Claim 1 has been amended to recite that:

- the entire cluster router appears to external communications networks and nodes as a single network attached router, as described in paragraph [80] of the original specification;
- the special purpose router cluster nodes are connected in the lattice of the cluster router, as described for example in paragraphs [70], [72], and [73] of the original specification; and
- the cluster-node-centric cluster router node configurations take into account the fact that the special purpose cluster nodes cannot be counted on to be aware of, or be configured via, the distributed cluster-node-centric router cluster node configuration, as described in the last sentence of paragraph [76] of the original specification.

In addition, the "reduction in development. . ." clause at the end of claim 1 has been deleted and claims 17 and 26 have been amended to clarify that the "equivalency" of the router cluster nodes has to do with the inclusion, in each of the router cluster nodes, of at least one external link, as explained in the last two sentences of paragraph [57] of the original specification

2. "Enablement Issues"

In item 4 of the Official Action, the Examiner mentions several "enablement issues" without actually rejecting the claims.

Although the Applicant disagrees that any of the claim limitations lack enablement, the "providing a reduction" recitation in claim 1 and the "computer platform providing flexibility and cost savings. . ." in claim 17 have been canceled.

In addition, the special purpose router cluster node of claim 1 has been defined in the claim as a router cluster node in the lattice of the cluster router that provides packet routing functionality not provided by others of the router cluster nodes and that, unlike the other router cluster nodes, "cannot be counted on to perform routing functions performed by others of said router cluster nodes," thereby addressing the statement in the Official Action that "it is unclear as to what constitutes a special purpose router entails as opposed to a normal router."

Finally, it is noted that the specification lists a number of "packet response processing functionalities" including but not limited to "billing, encryption, decryption, stream encoding/decoding, video stream processing, authentication, directory services, etc." paragraph [69], lines 1-5, which are all covered by the phrase "special packet processing functionality" as used in claim 1.

3. Rejection of Claims 1-4, 7, 12-20, and 25-36 Under 35 USC §102(b) in view of U.S. Patent No. 7,146,421 (Syvanne)

This rejection is respectfully traversed on the grounds that the Syvanne patent does not disclose or suggest that:

- any of the router cluster nodes in the lattice are special purpose router cluster nodes arranged to perform special packet processing functions not performed by other nodes, and that the configuration distributed to each cluster node take into account "that said at least one special purpose router cluster node cannot be counted on to be aware of, or be configured via, said distributed cluster-node-centric router cluster node configuration," as recited in **claim 1** (Syvanne's nodes all appear to have the same routing functions, and there is no suggestion that the node configuration distributed to the nodes should take into account that at least one of the nodes in the cluster cannot be counted on to perform the routing functions of the other nodes (and therefore may need to be by-passed during internal routing); and
- **each** of the router cluster nodes have ***external*** **links** in addition to the internal links between cluster nodes, as recited in original **claim 1 and amended claims 17 and 26** (it is the inclusion of *external* links in each router that provides true scalability–which feature is not suggested by Syvanne).

Neither the claimed special purpose router cluster nodes, which are nodes in the router lattice that perform packet processing functions other than routing, nor the claimed external links in each router cluster node, as even remotely disclosed or suggested by the Syvanne patent.

The use of special purpose nodes that do not perform all routing functions is actually counterintuitive since one would expect routing efficiency to improve by using routers that all have an optimized, or at least the same, routing function. Certainly, Syvanne does not suggest inclusion of such special purpose router cluster nodes within a cluster, as recited in claim1. It is only with the hindsight provided by Applicant's own specification that the advantages of the special purpose router cluster node(s) become apparent, namely that packets only need to be routed through the special purpose router as necessary to meet special needs, such as video handling or encryption/description, and that the use of special purpose router cluster nodes can therefore eliminate redundant processing capabilities with a minimal affect on overall routing capacity.

The feature of including an external link in **each** router, which makes each router truly equivalent by eliminating the inherent distinction between edge and core or internal nodes, so that **each router cluster node may act as an entry, core, and/or exit router cluster node with respect to the packet traffic processed by the cluster router**, has the advantage of greatly simplifying cluster configuration and of providing for true scalability (meaning that an arbitrary number of additional router cluster nodes may be added while using the same basic configuration of each node and corresponding management functions). Nothing in the Syvanne patent appears to suggest a cluster router that eliminates the distinction between edge and core routers, and therefore Syvanne does not anticipate any of independent claims 1, 17, and 26, from which all of the claims of the application depend.

Because the Syvanne patent does not disclose all elements recited in claims corresponding 1-4, 7, 12-20, and 25-36, withdrawal of the rejection under 35 USC §102(b) is respectfully requested.

4. Rejection of Claims 5, 6, 11, and 21 Under 35 USC §103(a) in view of U.S. Patent Nos. 7,146,421 (Syvanne) and 7,170,895 (Wirth)

This rejection is respectfully traversed on the grounds that the Wirth patent, like the Syvanne patent, does not disclose or suggest that (a) any of the router cluster nodes in the lattice are special purpose router cluster nodes arranged to perform special packet processing functions not performed by other nodes, and (b) that each of the router cluster nodes have *external* links in addition to the internal links between cluster nodes, as recited in claims 1 and 17, from which claims 5, 6, 11, and 21 depend. Instead, while Wirth discloses a "toroidal mesh," the nodes have separate external interfaces and switching units, and no special packet processing nodes. Therefore, withdrawal of the rejection of claims 5, 6, 11, and 21 under 35 USC §103(a) is respectfully requested.

5. Rejection of Claims 8-9 Under 35 USC §103(a) in view of U.S. Patent Nos. 7,146,421 (Syvanne) and 7,239,605 (Dinker)

This rejection is respectfully traversed on the grounds that the Dinker patent, like the Syvanne patent, does not disclose or suggest that (a) any of the router cluster nodes in the lattice are special purpose router cluster nodes arranged to perform special packet processing functions not performed by other nodes, and (b) that each of the router cluster nodes have *external* links in addition to the internal links between cluster nodes, as recited in claim 1, from which claims

8 and 9 depend. Instead, the Dinker patent is directed to replication of data in a failed node and does not disclose any particular cluster topology (Dinker's data replication could be useful in a wide variety of cluster topologies). Therefore, withdrawal of the rejection of claims 8 and 9 under 35 USC §103(a) is requested.

6. Rejection of Claims 10 and 22-24 Under 35 USC §103(a) in view of U.S. Patent Nos. 7,146,421 (Syvanne) and 7,069,317 (Colrain)

This rejection is respectfully traversed on the grounds that the Colrain patent, like the Syvanne patent, does not disclose or suggest that (a) any of the router cluster nodes in the lattice are special purpose router cluster nodes arranged to perform special packet processing functions not performed by other nodes, and (b) that each of the router cluster nodes have *external* links in addition to the internal links between cluster nodes, as recited in original claim 1 and amended claim 17, from which claims 10 and 22-24 depend. To the contrary, the Colrain patent is directed to a notification system and method, and does not disclose any sort of cluster router. Therefore, withdrawal of the rejection of claims 10 and 22-24 under 35 USC §103(a) is requested.

Having thus overcome each of the rejections made in the Official Action, withdrawal of the rejections and expedited passage of the application to issue is requested.

Respectfully submitted,
BACON & THOMAS, PLLC

Date: July 7, 2008

By: BENJAMIN E. URCIA
Registration No. 33,805

Serial Number 10/712,104

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/712,104	11/14/2003	Peter Rabinovitch	3465-Z	8217

7590 04/07/2008

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EXAMINER	
POLLACK, MELVIN H	
ART UNIT	PAPER NUMBER
2145	

MAIL DATE	DELIVERY MODE
04/07/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/712,104	RABINOVITCH, PETER	
	Examiner	Art Unit	
	MELVIN H. POLLACK	2145	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *02 January 2008*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-19,21-26 and 28-36* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-19,21-26 and 28-36* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *14 November 2003* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☒ Other: *see attached office action*.

DETAILED ACTION

Response to Arguments

1. Applicant's arguments filed 02 January 2008 have been fully considered but they are not persuasive. An analysis of the arguments is provided below.

2. Examiner withdraws the objection to the abstract in light of the amendment.

3. In response to applicant's argument that the references fail to show certain features of applicant's invention, it is noted that the features upon which applicant relies (i.e., the purpose of the invention is to "provide a low-cost router that is flexible and scaleable in routing capacity and port counts (P. 13, lines 14-15)") are not recited in the rejected claim(s). Although the claims are interpreted in light of the specification, limitations from the specification are not read into the claims. See *In re Van Geuns*, 988 F.2d 1181, 26 USPQ2d 1057 (Fed. Cir. 1993). While some of the limitations in claims 1 and 20 may hint at such a purpose, these limitations need to be clarified.

4. Clarifications are also required for items that may have enablement issues. In particular, it is unclear whether the result of "providing a reduction" is sufficiently enabled with regard to its tangibility and functionality. It is also unclear as to what constitutes a special purpose router entails as opposed to a normal router. Applicant may have also failed to enable what and how a router cluster node may comprise a personal computer platform providing flexibility and cost savings in the development, deployment, maintenance, and expandability of the cluster router.

5. For the purposes of this action, the examiner will define such terms as broadly as reasonable. Applicant should consider amending the specification in regards to any potentially incorrect interpretations.

6. Applicant argues that router cluster nodes 700a, 700b, and 700c are indistinguishable, and therefore, none of them can be a special purpose node (P. 15, lines 14-21). Presuming this to be true for the sake of advancing prosecution, the applicant fails to note that router cluster 800 also includes a special node 802, with components 804 and 806. Such a node is compared with Fig. 2, wherein "in step 202 a distribution identifier is calculated for a data packet… and in step 204 the data packet is handled in that node of said network element cluster, to which node the distribution identifier belongs (col. 8, lines 10-20)." More specifically, "the network element cluster 800 further comprises means 802 for allocating/reallocating to each node belonging to said network element cluster certain node-specific distribution identifiers, each node having separate node-specific identifiers allocated to it…. The cluster further includes means 804 for load balancing and means 806 for node monitoring…. Means 802, 804 and 806 may be implemented as a part of one of the nodes, or they may be included in a separate device (col. 17, lines 7-23)." Said citations also rebut the applicant's argument that Syvanne does not show a "provisioned router-cluster-node-centric configuration distributed to each router cluster node" to help in distributing packet routing, and that Syvanne fails to show a packet processing flow (P. 16, lines 4-23).

7. Applicant further argues that, in regards to claims 3 and 17, applicant does not expressly disclose that each router cluster node comprises a "personal computer platform (P. 16, lines 1-2)." The examiner interprets this term in the broadest reasonable interpretation, and in light of the potential enablement, wherein there must be a client somewhere in the node. However, this is at least inherent, since the routing of packets indicates that there must be at lease one

transmitter and one receiver. Such a limitation is taught in Fig. 1A, which must be used to properly view Figs. 2 and 8.

8. Therefore, the rejection is maintained for the reasons above, and is final.

Claim Rejections - 35 USC § 102

9. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

10. Claims 1-4, 7, 12-20, and 25-36 are rejected under 35 U.S.C. 102(e) as being anticipated by Syvanne (7,146,421).

11. Syvanne teaches a method and system (abstract) of providing a collection of nodes to perform routing (col. 1, line 1 – col. 7, line 50) via a variety of connections and configurations (col. 16, line 20 – col. 18, line 5), wherein packets are distributed based on a tag within a packet header (col. 7, lines 45-65; col. 11, lines 15-55) to create load balancing (col. 8, lines 1-20). In particular, functional blocks are routed based on tags (col. 8, lines 20-55), with backups produced for resiliency to failure (col. 8, lines 55-60), and thus producing a routing capacity of type O(N) (col. 9, lines 3-65).

Claim Rejections - 35 USC § 103

12. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

13. Claims 5, 6, 11, and 21 are rejected under 35 U.S.C. 103(a) as being unpatentable over Syvanne as applied to claim1 and 17 above, and further in view of Wirth et al. (7,170,895).

14. Syvanne does not expressly disclose a toroidal, 3-dimensional, bus topology. Wirth teaches a method and system (abstract) of network switching nodes (col. 1, line 1 – col. 6, line 45; col. 16, line 55 – col. 17, line 20) that teaches this limitation (col. 6, line 45 – col. 9, line 40, esp. col. 7, lines 10-30). At the time the invention was made, one of ordinary skill in the art would have combined the inventions in order to provide further fault tolerance (col. 1, lines 50-60).

15. Claims 8-9 are rejected under 35 U.S.C. 103(a) as being unpatentable over Syvanne as applied to claim 1 above, and further in view of Dinker et al. (7,239,605).

16. Syvanne does not expressly disclose the usage of manager backup nodes, although it does disclose a backup node system (see above). Dinker teaches a method and system (abstract) of providing to a cluster node topology a backup process (col. 1, line 1 – col. 4, line 50; col. 12, line 60 – col. 13, line 5) in which the limitations are disclosed (col. 4, line 50 – col. 8, line 20). At the time the invention was made, one of ordinary skill in the art would have added Dinker in order to ensure self-healing in times of high demand (col. 1, lines 35 – 60).

17. Claims 10 and 22-24 are rejected under 35 U.S.C. 103(a) as being unpatentable over Syvanne as applied to claims 1 and 17 above, and further in view of Colrain et al. (7,069,317).

18. Syvanne does not expressly disclose configuring and reporting out of band. Colrain teaches a method and system (abstract) of node management (col. 1, line 1 – col. 4, line 30; col. 12, lines 63 - 67) wherein changes and notifications are made out of band (col. 4, line 30 – col. 5, line 5). At the time the invention was made, one of ordinary skill in the art would have combined the inventions in order to better handle system failures (col. 2, lines 15-25).

Conclusion

19. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MELVIN H. POLLACK whose telephone number is (571)272-3887. The examiner can normally be reached on 8:00-4:30 M-F.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jason Cardone can be reached on (571) 272-3933. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/M. H. P./
Examiner, Art Unit 2145
31 March 2008

/Jason D Cardone/
Supervisory Patent Examiner, Art Unit 2145

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10712104	RABINOVITCH, PETER
	Examiner	Art Unit
	MELVIN H POLLACK	2145

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	03/17/2008								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
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	27	-								
	28	✓								
	29	✓								
	30	✓								
	31	✓								
	32	✓								
	33	✓								
	34	✓								
	35	✓								
	36	✓								

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10712104	RABINOVITCH, PETER
	Examiner	Art Unit
	MELVIN H POLLACK	2145

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

Atty. Docket No.: 3465-Z

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

Peter Rabinovitch — Examiner Melvin H. Pollack

Serial No. 10/712,104 — Group Art Unit 2145

Filed: November 14, 2003

For: Software Configurable Cluster-Based Router Using Heterogeneous Nodes as Cluster Nodes

AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Official Action mailed August 1, 2007 please amend the above-identified application as follows:

Amendments to the Specification:

Replace the abstract with the following amended abstract:

A cluster router architecture and methods for performing distributed routing are presented. The cluster router architecture includes off-the shelf Personal Computer (PC) hardware-based router cluster nodes interconnected in an intra-connection network in multiple dimensions. Each PC-based router cluster node is provided with the same routing functionality and a router-cluster-node-centric configuration enabling each router cluster node ~~by itself or multiple router cluster nodes in the cluster router~~ to provide routing responses for packets pending processing. ~~Optimized packet processing in respect of specific functionality is provided via special purpose router cluster nodes not necessarily PC based taking part as cluster nodes in the cluster router lattice. The method divides packet~~ Packet processing is divided into entry packet processing and routing response processing; special processing; and exit processing. ~~Entry packet processing and routing response processing is performed by router cluster nodes receiving packets from communication networks in which the cluster router participates.~~ Exit packet processing is performed by router cluster nodes transmitting packets into communication networks in which the cluster router participates. Packet processing ~~in accordance with the router cluster node centric specification~~ is interrupted on determining that special processing is required in

respect of a packet, and the packet is handed over to a corresponding special purpose router cluster node. ~~Advantages are derived from: a configurable, and scalable cluster router design providing a re configurable high routing capacity using cost effective stock PC hardware; from the infra connection network which provides a high degree of diversity ensuring resilience to equipment failure; from the use of a star topology with respect to management links which reduces management overheads in the intra-connection network; and from the ability to forward packets to designated special purpose router cluster nodes optimized to provide specific packet processing functionality~~.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

1. (CURRENTLY AMENDED) A cluster-based router comprising:
   a. a plurality of interconnected router cluster nodes, the routing capacity of the cluster router increasing substantially O(N) with the number N of router cluster nodes in the cluster router, each router cluster node having a group of cluster router external links enabling packet exchange with a plurality of external communication network nodes;
   b. at least one special purpose cluster node providing special packet processing functionality in the cluster router;
   c. a plurality of cluster router internal links interconnecting cluster nodes forming an intra-connection network ensuring a high path diversity in providing resiliency to failures; and
   d. a provisioned router-cluster-node-centric configuration distributed to each router cluster node for operating in accordance therewith in effecting distributed routing of the conveyed packets,

employing the at least one special purpose router cluster node ~~providing~~ to provide a reduction in the development, validation, deployment and reconfiguration of the cluster router.

2. (ORIGINAL) The cluster router claimed in claim 1, wherein the router-cluster-node-centric configuration further comprises routing functional blocks and specifies packet processing flows between the routing functional blocks effecting packet processing

employing one of: a single router cluster node, and a group of cluster nodes.

3. (ORIGINAL) The cluster router claimed in claim 1, wherein each router cluster node further comprises a personal computer platform providing flexibility and cost savings in the development, deployment, maintenance, and expandability of the cluster router.

4. (ORIGINAL) The cluster router claimed in claim 1, wherein at least one special purpose cluster node providing special packet processing functionality further comprises one of: a specially coded personal computer platform, a personal computer platform having designed hardware characteristics in providing specific functionality/ dedicated hardware implemented equipment designed to provide an enhancement in providing special packet processing functionality/ and a router cluster node further coded to provide special packet processing functionality.

5. (ORIGINAL) The cluster router claimed in claim 1, wherein the intra-connection network further comprises an n dimensional toroidal topology, wherein 2*n internal links interconnect each router cluster node with 2*n adjacent neighboring router cluster nodes; the routing capacity of the cluster router being increased substantially linearly by adding an n-1 dimensional slice of router cluster nodes to the cluster router.

6. (ORIGINAL) The cluster router claimed in claim 5, wherein the intra-connection network comprises a three dimensional toroidal topology, wherein six internal links interconnect each router cluster node with six adjacent neighboring router cluster nodes.

7. (ORIGINAL) The cluster router claimed in claim 1, wherein the intra-connection network further comprises one of unidirectional and bi-directional internal interconnecting links.

8. (ORIGINAL) The cluster router claimed in claim 1, further comprising: a router cluster node designated as a management node, should a management node designated router cluster node fail, another router cluster node being designated as a management node without making changes to the cluster router infrastructure.

9. (ORIGINAL) The cluster router claimed in claim 1, further comprising: a router cluster node designated as a special purpose cluster node, should a special purpose cluster node designated router cluster node fail, another router cluster node being designated as a special purpose cluster node without making changes to the cluster router infrastructure.

10. (ORIGINAL) The cluster router claimed in claim 1, further comprising:

a. at least one management node; and

b. a plurality of management links interconnecting the at least one management node with the plurality of router cluster nodes and enabling one of out-of-band: configuration deployment to each router cluster node, router cluster node initialization, and reporting functionality,

employing the plurality of management links reducing an in-band cluster router management overhead.

11. (ORIGINAL) The cluster router claimed in claim 10, wherein the plurality of management links from one of a star and a bus topology.

12. (ORIGINAL) The cluster router claimed in claim 11, wherein the at least one special purpose cluster node is associated with the management node, special functionality being available one-hop-away from each router cluster node.

13. (ORIGINAL) The cluster router claimed in claim 1, further comprising an cluster router internal addressing process dynamically determining router cluster node addressing.

14. (ORIGINAL) The cluster router claimed in claim 1, further comprising a cluster router external addressing process dynamically determining a cluster router address.

15. (ORIGINAL) The cluster router claimed in claim 1, further comprising means for distributing to each router cluster node information regarding availability and addressing information regarding special purpose cluster nodes.

16. (ORIGINAL) The cluster router claimed in claim 15, further employing methods of detecting special purpose cluster nodes providing special packet processing functionality.

17. (CURRENTLY AMENDED) A router cluster node of a plurality of router cluster nodes interconnected in a cluster router, [[the]] <u>each</u> router cluster node comprising:

a. a plurality of cluster router internal interconnecting links connected thereto, the internal interconnecting links enabling the exchange of packets with adjacent cluster nodes in the cluster router;

b. at least one cluster router external link connected thereto, the at least one external link enabling exchange of packets between external communications network nodes and the cluster router; [[and]]

c. a router-cluster-node-centric configuration to effect distributed routing of the conveyed packets, and wherein each router cluster node comprises a personal computer platform providing flexibility and cost savings in the development, deployment, maintenance, and expandability of the cluster router;

the equivalency between router cluster nodes in the cluster router providing a scalable router.

18. (ORIGINAL) The router cluster node claimed in claim 17, wherein the router-cluster-node-centric configuration further comprises routing functional blocks and specifies packet processing flows between the routing functional blocks effecting packet routing employing one of: a single router cluster node, and a group of router cluster nodes.

19. (ORIGINAL) The router cluster node claimed in claim 18, wherein the router-cluster- node-centric configuration further comprises routing functional blocks determining a need for special packet processing and specifies packet processing flows forwarding packets to at least one special purpose cluster node associated with the router cluster.

Claim 20. (CANCELLED)

21. (ORIGINAL) The router cluster node claimed in claim 17, wherein 2*n cluster router internal links interconnect the router cluster node with 2*n adjacent neighboring router cluster nodes in accordance with an n dimensional toroidal topology, the routing capacity of the cluster router being increased substantially linearly by adding an n-1 dimensional slice of router cluster nodes to the cluster router.

22. (ORIGINAL) The router cluster node claimed in claim 17, further comprising: a management link interconnecting the router cluster node to a management node.

23. (ORIGINAL) The router cluster node claimed in claim 17, further providing management functionality.

24. (ORIGINAL) The router cluster node claimed in claim 17, further providing special packet processing functionality as a special purpose cluster node.

25. (ORIGINAL) The router cluster node claimed in claim 24, wherein the special purpose cluster node provides packet processing in respect one of: authentication, decryption, encryption, decoding, encoding, billing, directory access, and video stream processing.

26. (CURRENTLY AMENDED) A router-cluster-node-centric configuration enabling the provision of a distributed packet routing response in a cluster router having a plurality of router cluster nodes, the configuration comprising:

a. a plurality of routing functional blocks; [[and]]

b. at least one router-cluster-node-centric packet processing flow, via the plurality of routing functional blocks, to effect routing of packets received at the cluster router employing one of a single router cluster node and a group of router cluster nodes[[.]];

c. an entry-and-routing processing packet processing flow specification;

d. a transit packet processing flow specification; and

e. an exit packet processing packet processing flow specification,

the packet processing flow specifications enabling a received packet to undergo entry and routing processing at an entry router cluster node, optionally transit via at least one intermediary router cluster node, and undergo exit processing at an exit router cluster node.

Claim 27. (CANCELLED)

28. (ORIGINAL) The router-cluster-node-centric configuration claimed in claim 26, wherein the router cluster node configuration further employs a tag conveyed with each packet within the cluster router infrastructure, the tag holding specifiers for tracking packet processing within the cluster router.

29. (ORIGINAL) The router-cluster-node-centric configuration claimed in claim 28, wherein each tag identifies an associated packet as one having received a routing response and propagating through the cluster router towards a specified exit router cluster node.

30. (ORIGINAL) The router-cluster-node-centric configuration claimed in claim 28, wherein each tag identifies an associated packet as one requiring special processing and propagating through the cluster router towards one of: a special purpose cluster node, and the router cluster node which determined that the packet required special processing.

31. (ORIGINAL) The router-cluster-node-centric configuration claimed in claim 28, wherein each tag comprises a combination of: an optional packet header, a packet trailer, and an additional header encapsulating the associated packet having cluster router relevance only.

32. (ORIGINAL) The router-cluster-node-centric configuration claimed in claim 28, wherein each tag holds a tag time-to-live specification decremented while the associated packet propagates via router cluster nodes in the cluster, the packet being discarded when the time-to-live specification is zero and the packet has not reached a corresponding exit router cluster node thereby reducing transport overheads.

33. (ORIGINAL) A router-cluster-node-centric configuration enabling the provision of a distributed packet routing response in a cluster router having a plurality of router cluster nodes and at least one special purpose cluster node as claimed in claim 26, the configuration further comprising:

a. at least one routing functional block determining a need for special functionality in respect of processing a packet; and

b. at least one router-cluster-node-centric packet processing flow effecting forwarding of the packet to a special purpose cluster node for processing.

34. (ORIGINAL) The router-cluster-node-centric configuration claimed in claim 33, wherein the at least one router-cluster-node-centric packet processing flow further specifies one of: storing a copy of the packet header and a corresponding tag in an optional header of the packet; and storing information about the packet in a storage structure for the purposes of continuing packet processing in accordance with the router-cluster-node-centric configuration.

35. (ORIGINAL) The router-cluster-node-centric configuration claimed in claim 33, wherein the at least one cluster-node-centric packet processing flow further specifies at least one

packet processing flow for further processing a packet having undergone packet processing at a special purpose cluster node.

36. (ORIGINAL) The router-cluster-node-centric configuration claimed in claim 33, wherein the at least one cluster-node-centric packet processing flow further specifies employing addressing information stored in the packet header in forwarding the packet requiring special processing towards a special purpose cluster node.

REMARKS/ARGUMENTS

The abstract has been amended to reduce the length thereof. The terms and phrases: "The disclosure concerns", "The disclosure defined by this invention" and "The disclosure describes" are not used in the abstract.

Claims 1 - 19, 21-26 and 28 - 36 remain pending in the application.

Claims 20 and 27 have been cancelled.

Claims 1, 17, and 26 have been amended.

The rejection of claims 1 - 4, 7, 12 - 20 and 25 - 36 under 35 U.S.C. 102(e) as being anticipated by Syvanne (US 7,146,421) is respectfully traversed.

As set out in the specification at page 1 *et seq*, the problem solved by the invention is to provide a low-cost router that is flexible, and scaleable in routing capacity and port counts. The specification at pages 1 - 9 provides an extensive discussion of prior art attempts and approaches to solve this problem. The solution provided by Syvanne falls in these prior art solutions.

Syvanne is directed to handling state information in a network element cluster and state information is defined in col. 2, lines 35-61 of Syvanne; and Fig. 2 discloses the basic flow chart which is reproduced as follows:

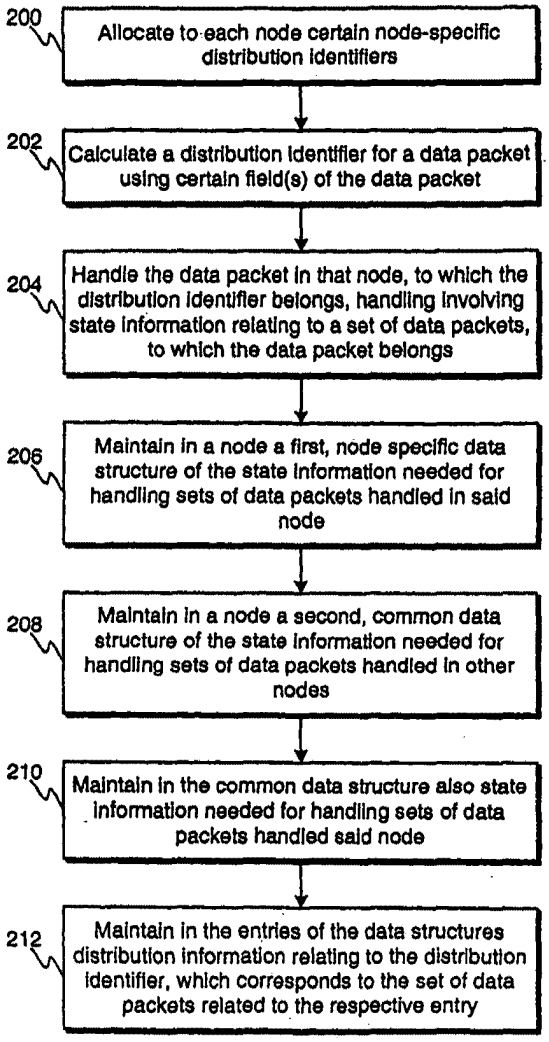

Fig. 2

Fig. 7 of Syvanne illustrates the network element node, and Fig. 8 illustrates a network element cluster.

In no case is there disclosed a teaching or suggestion of:

> ...at least one special purpose cluster node providing special packet processing functionality in the cluster router;...
>
> ...a provisioned router-cluster-node centric configuration distributed to each router cluster

> node for operating in accordance therewith in effecting distributed routing of the conveyed packets,
>
> employing the at least one special purpose router cluster node to provide a reduction in the development, validation, deployment and reconfiguration of the cluster router

as recited in claim 1.

In Fig. 8 of Syvanne, the network element cluster comprises a plurality of network element nodes such as shown in Fig. 7 and which are provided with the capability of communicating with one another. None of the element nodes 700a, 700b, 700c, etc. is the same as or equivalent to applicant's: "at least special purpose cluster node providing special packet processing functionality in the cluster router." Nor is there shown in Figs. 7 or 8 or any of the flow charts of Syvanne a "provisioned router-cluster-node-centric configuration distributed to each router cluster node for operating in accordance therewith in effecting distributed routing of the conveyed packets" as also recited in applicant's claim 1.

Claim 17 has been amended to include the subject matter of claim 20 and distinguishes over the Syvanne reference in reciting:

> c. a router-cluster-node-centric configuration to effect distributed routing of the conveyed packets, and
> d. wherein each router cluster node comprises a personal computer platform providing flexibility and cost savings in the development, deployment, maintenance, and expandability of the cluster router.

The claims dependent from claim 17 are patentable over the art for the same reason.

There is no mention in Syvanne of: "each router cluster node comprises a personal computer platform." In fact, there is no mention in Syvanne of personal computers at all.

Independent claim 26 has been amended to include the subject matter of claim 27 and distinguishes over the Syvanne reference in requiring:

> b. at least one router-cluster-node-centric packet processing flow, via the plurality of routing functional blocks, to effect routing of packets received at the cluster router employing one of a single router cluster node and a group of router cluster nodes;
> c. an entry-and-routing processing packet processing flow specification;
> d. a transit packet processing flow specification; and
> e. an exit packet processing packet processing flow specification,
>
> the packet processing flow specifications enabling a received packet to undergo entry and routing processing at an entry router cluster node, optionally transit via at least one intermediary router cluster node, and undergo exit processing at an exit router cluster node.

No such teaching or equivalent thereof is found in Syvanne.

The rejection of claims 5, 6, 11 and 21 under 35 U.S.C. 103(a) as being unpatentable over Syvanne further in view of Wirth et al (US 7.170,895) (hereinafter Wirth) is respectfully traversed. Syvanne has been shown to not be anticipatory of the independent claims, and it follows that dependent claims in the application are patentable for the reason given above; and hence the combination of Syvanne and Wirth does not teach the invention defined by claims 5, 6, 11 and 21.

The rejection of claims 8 and 9 under 35 U.S.C. 103(a) as being unpatentable over Syvanne and further in view of Dinker et al (US 7,239,605) (hereinafter Dinker) is respectfully traversed. As shown above, Syvanne does not disclose, teach or suggest the invention defined in parent claim 1; and hence does not teach or suggest the invention defined in dependent claims 8 and 9.

The rejection of claims 10 and 22-24 under 35 U.S.C. 103(a) as being unpatentable over Syvanne and further in view of Colrain et al (US 7,069,317) (hereinafter Colrain) is respectfully traversed. As shown above, Syvanne does not disclose, teach or suggest the subject matter of independent claims 1 and 17; and hence does not teach or suggest the combination proposed by the Examiner.

In view of the above, further and favorable reconsideration is respectfully requested.

Respectfully submitted,

Jim Zegeer

Jim Zegeer, Reg. No. 18,957
Attorney for Applicants

Suite 108
801 North Pitt Street
Alexandria, VA 22314
Telephone: 703-684-8333

Date: January 2, 2008

In the event this paper is deemed not timely filed, the applicant hereby petitions for an appropriate extension of time. The fee for this extension may be charged to Deposit Account No. 26-0090 along with any other additional fees which may be required with respect to this paper.

Attorney Ref: 3465-Z

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of
Peter Rabinovitch
Serial No. 10/712,104
Filed: November 14, 2003
For: Software Configurable Cluster-Based Router Using Heterogeneous Nodes as Cluster Nodes

Examiner Melvin H. Pollack
Group Art Unit 2145

PETITION FOR EXTENSION OF RESPONSE PERIOD UNDER 37 C.F.R.1.136(a)

Mail Stop FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Transmitted herewith is a response to the outstanding Office Action.

This is a request under the provisions of 37 C.F.R. §1.136(a) to extend the period for filing a reply in the above-identified application.

The request extension and fee are as follows:

	Fee	Small Entity Fee	
☐ One month (37 C.F.R. 1.17(a)(1))	$ 120	$ 60	$____
☒ Two months (37 C.F.R. 1.17(a)(2))	$ 460	$ 230	$ 460
☐ Three months (37 C.F.R. 1.17(a)(3))	$1050	$ 525	$____

☐ Applicant claims small entity status. See 37 C.F.R. §1.27.

☒ A check in the amount of the fee is enclosed.

☒ The Director is hereby authorized to charge any additional fees which may be required, or credit any overpayment, to Deposit Account No. 26-0090.

Respectfully submitted,

Jim Zegeer

Jim Zegeer, Reg. No. 18,957
Attorney for Applicant

Suite 108
801 North Pitt Street
Alexandria, VA 22314
Telephone: 703-684-8333

01/03/2008 MAHMED1 00000002 10712104
01 FC:1252 460.00 OP

Date: January 2, 2008

In the event this paper is deemed not timely filed, the applicant hereby petitions for an appropriate extension of time. The fee for this extension may be charged to Deposit Account No. 26-0090 along with any other additional fees which may be required with respect to this paper.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PATENT APPLICATION FEE DETERMINATION RECORD
Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
10/712,104	11/14/2003	

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT 01/02/2008	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 34	Minus	** 36	= 0	X $ =		OR	X $50=	0
Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $ =		OR	X $210=	0
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

AMENDMENT	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
Brenda Harrison

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/712,104	11/14/2003	Peter Rabinovitch	3465-Z	8217

7590 08/01/2007

Law Office of Jim Zegeer
Suite 108
801 North Pitt Street
Alexandria, VA 22314

EXAMINER	
POLLACK, MELVIN H	
ART UNIT	PAPER NUMBER
2145	

MAIL DATE	DELIVERY MODE
08/01/2007	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/712,104	RABINOVITCH, PETER	
	Examiner	Art Unit	
	Melvin H. Pollack	2145	

-- *The MAILING DATE of this communication appears on the cover sheet with the correspondence address* --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *14 November 2003*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-36* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-36* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *14 November 2003* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *3/5/04*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☒ Other: *see attached office action*.

DETAILED ACTION

Specification

1. Applicant is reminded of the proper language and format for an abstract of the disclosure.

The abstract should be in narrative form and generally limited to a single paragraph on a separate sheet within the range of 50 to 150 words. It is important that the abstract not exceed 150 words in length since the space provided for the abstract on the computer tape used by the printer is limited. The form and legal phraseology often used in patent claims, such as "means" and "said," should be avoided. The abstract should describe the disclosure sufficiently to assist readers in deciding whether there is a need for consulting the full patent text for details.

The language should be clear and concise and should not repeat information given in the title. It should avoid using phrases which can be implied, such as, "The disclosure concerns," "The disclosure defined by this invention," "The disclosure describes," etc.

2. The abstract of the disclosure is objected to because it is too long. Correction is required.

See MPEP § 608.01(b).

Claim Rejections - 35 USC § 102

3. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

4. Claims 1-4, 7, 12-20, and 25-36 are rejected under 35 U.S.C. 102(e) as being anticipated by Syvanne (7,146,421).

5. Syvanne teaches a method and system (abstract) of providing a collection of nodes to perform routing (col. 1, line 1 – col. 7, line 50) via a variety of connections and configurations (col. 16, line 20 – col. 18, line 5), wherein packets are distributed based on a tag within a packet

header (col. 7, lines 45-65; col. 11, lines 15-55) to create load balancing (col. 8, lines 1-20). In particular, functional blocks are routed based on tags (col. 8, lines 20-55), with backups produced for resiliency to failure (col. 8, lines 55-60), and thus producing a routing capacity of type O(N) (col. 9, lines 3-65).

Claim Rejections - 35 USC § 103

6. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

7. Claims 5, 6, 11, and 21 are rejected under 35 U.S.C. 103(a) as being unpatentable over Syvanne as applied to claim1 and 17 above, and further in view of Wirth et al. (7,170,895).

8. Syvanne does not expressly disclose a toroidal, 3-dimensional, bus topology. Wirth teaches a method and system (abstract) of network switching nodes (col. 1, line 1 – col. 6, line 45; col. 16, line 55 – col. 17, line 20) that teaches this limitation (col. 6, line 45 – col. 9, line 40, esp. col. 7, lines 10-30). At the time the invention was made, one of ordinary skill in the art would have combined the inventions in order to provide further fault tolerance (col. 1, lines 50-60).

9. Claims 8-9 are rejected under 35 U.S.C. 103(a) as being unpatentable over Syvanne as applied to claim 1 above, and further in view of Dinker et al. (7,239,605).

10. Syvanne does not expressly disclose the usage of manager backup nodes, although it does disclose a backup node system (see above). Dinker teaches a method and system (abstract) of

providing to a cluster node topology a backup process (col. 1, line 1 – col. 4, line 50; col. 12, line 60 – col. 13, line 5) in which the limitations are disclosed (col. 4, line 50 – col. 8, line 20). At the time the invention was made, one of ordinary skill in the art would have added Dinker in order to ensure self-healing in times of high demand (col. 1, lines 35 – 60).

11. Claims 10 and 22-24 are rejected under 35 U.S.C. 103(a) as being unpatentable over Syvanne as applied to claims 1 and 17 above, and further in view of Colrain et al. (7,069,317).

12. Syvanne does not expressly disclose configuring and reporting out of band. Colrain teaches a method and system (abstract) of node management (col. 1, line 1 – col. 4, line 30; col. 12, lines 63 - 67) wherein changes and notifications are made out of band (col. 4, line 30 – col. 5, line 5). At the time the invention was made, one of ordinary skill in the art would have combined the inventions in order to better handle system failures (col. 2, lines 15-25).

Conclusion

13. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. They regard further teachings on router cluster nodes, failure resiliency, and load balancing.

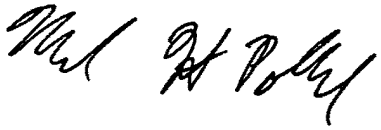
Any inquiry concerning this communication or earlier communications from the examiner should be directed to Melvin H. Pollack whose telephone number is (571) 272-3887. The examiner can normally be reached on 8:00-4:30 M-F.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jason Cardone can be reached on (571) 272-3933. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Melvin H Pollack
Examiner
Art Unit 2145

MHP
26 July 2007



FORM PTO-1449 (MODIFIED) U.S. Department of Commerce Patent and Trademark Office	ATTY. DOCKET NO. 3465-Z	SERIAL NO. 10/712,104
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use several sheets if necessary)	APPLICANT Peter Rabinovitch	
	FILING DATE November 14, 2003	GROUP 1058

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc.)

/MHP/	1.	Kohler et al, "The Click Modular Router", Laboratory for Computer Science, Massachusetts Institute of Technology, Date: 2000, pages 1-34.
	2.	Kohler, "The Click Modular Router", Submitted to the Department of Electrical Engineering and Computer Science in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the Massachusetts Institute of Technology, February 2001 (pages 1-127).
	3.	Cecchet, SciFS TECHNICAL & PRACTICAL GUIDE, Release 26, INRIA Rhone-Alpes SIRAC Laboratory (Pages 1-73), http://sci-serv.inrialpes.fr
	4.	Cecchet, "What is SciFS?", SciFS: A Distributed Shared Virtual Memory for SCI Cluster", http://sci-serv.inrialpes.fr/SciOS/whatis_scios.html (2 sheets).
	5.	Gilbert et al, "Scalable Routing Through Clusters", Department of Computer Science, Duke University, Durham, N.C., Published on the Internet at http://www.cs.duke.edu/~marty/cbr/ (5 sheets), 1999-12-15
	6.	Appenzeller et al, "Can Google Route?", Q2/2002 (21 sheets)
/MHP/	7.	Chen et al, "Flexible Control of Parallelism in a Multiprocessor PC Router", published in the Proceedings of the USENIX 2001 Annual Technical Conference, June 2001 (pages 1-14).

EXAMINER /Melvin Pollack/	DATE CONSIDERED 07/19/2007

EXAMINER: Initial if citation is considered, draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Notice of References Cited	Application/Control No. 10/712,104	Applicant(s)/Patent Under Reexamination RABINOVITCH, PETER	
	Examiner Melvin H. Pollack	Art Unit 2145	Page 1 of 2

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-7,146,421	12-2006	Syvanne, Tuomo	709/226
*	B	US-7,170,895	01-2007	Wirth et al.	370/400
*	C	US-7,239,605	07-2007	Dinker et al.	370/216
*	D	US-7,069,317	06-2006	Colrain et al.	709/224
*	E	US-7,103,664	09-2006	Novaes et al.	709/226
*	F	US-7,003,574	02-2006	Bahl, Pradeep	709/228
*	G	US-7,120,681	10-2006	Frelechoux et al.	709/221
*	H	US-7,117,242	10-2006	Cherkasova et al.	709/203
*	I	US-6,954,784	10-2005	Aiken et al.	709/220
*	J	US-7,231,461	06-2007	Laschkewitsch et al.	709/248
*	K	US-7,058,846	06-2006	Kelkar et al.	714/4
*	L	US-7,146,432	12-2006	Antes et al.	709/239
*	M	US-7,165,120	01-2007	Giles et al.	709/249

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
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	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Notice of References Cited	Application/Control No. 10/712,104	Applicant(s)/Patent Under Reexamination RABINOVITCH, PETER	
	Examiner Melvin H. Pollack	Art Unit 2145	Page 2 of 2

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-6,986,076	01-2006	Smith et al.	714/4
*	B	US-7,130,266	10-2006	Virtanen et al.	370/230
*	C	US-7,139,925	11-2006	Dinker et al.	714/4
*	D	US-7,043,562	05-2006	Dally et al.	709/238
*	E	US-7,139,819	11-2006	Luo et al.	709/223
*	F	US-2005/0018665	01-2005	Jordan et al.	370/388
*	G	US-2005/0097206	05-2005	Rabinovitch et al.	709/224
	H	US-			
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	J	US-			
	K	US-			
	L	US-			
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FOREIGN PATENT DOCUMENTS

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NON-PATENT DOCUMENTS

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*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims

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√	Rejected	–	(Through numeral) Cancelled	N	Non-Elected	A	Appeal
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Claim		Date
Final	Original	7/25/07
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Search Notes

Application/Control No.	Applicant(s)/Patent under Reexamination
10/712,104	RABINOVITCH, PETER
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Melvin H. Pollack	2145

SEARCHED			
Class	Subclass	Date	Examiner
709	221, 232-235, 238-241, 246	7/26/2007	MHP
	252, 253		
370	216-220		
	229, 230		
	230.1		
	237, 238		
	240, 244		
	257, 389		
713	1, 2, 100		
714	4		

INTERFERENCE SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES (INCLUDING SEARCH STRATEGY)		
	DATE	EXMR
EAST - Search Notes Addendum	7/26/2007	MHP

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	16	rabinovitch.in. near2 peter.in.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/07/25 13:01
S2	4	S1 and @ad<="20031114"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/07/25 13:04
S3	29269	alcatel.as.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/07/25 13:04
S4	24518	S3 and @ad<="20031114"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/07/25 13:07
S5	2837	S4 and rout$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/07/25 13:07
S6	1079	S5 and configur$6	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/07/25 13:08
S7	37	S6 and cluster	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/07/25 13:08

EAST Search History

S8	20892	(709/221 or 709/232 or 709/233 or 709/234 or 709/235 or 709/238 or 709/239 or 709/240 or 709/241 or 709/246 or 709/252 or 709/253 or 370/216 or 370/217 or 370/218 or 370/219 or 370/220 or 370/229 or 370/230 or 370/230.1 or 370/237 or 370/238 or 370/240 or 370/244 or 370/257 or 370/389 or 713/1 or 713/2 or 713/100 or 714/4).ccls. and @ad<="20031114"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/07/25 13:21
S9	1819	cluster adj node	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/07/25 13:22
S10	209	S8 and S9	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/07/25 14:43
S11	1145	topology near2 (toroid$4 or dimension$4 or 3D or "3-D")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/07/25 14:44
S12	466	S11 and (router or routing or route)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/07/25 14:45
S13	737	S11 and (configur$6)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/07/25 14:45

EAST Search History

S14	368	S12 and S13	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/07/25 14:45
S15	297	S14 and @ad<="20031114"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/07/25 14:46

Atty. Docket No.: 3465-Z

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of
Peter Rabinovitch
Serial No. 10/712,104 Group Art Unit 1058
Filed: November 14, 2003
For: Software Configurable Cluster-Based Router Using Heterogeneous Nodes as Cluster Nodes

INFORMATION DISCLOSURE STATEMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

This Information Disclosure Statement is submitted:

[X] under 37 CFR 1.97(b), or
(Within three months of filing national application; or date of entry of international application; or before mailing date of first Office action on the merits; whichever occurs last.)

[] under 37 CFR 1.97(c) together with either a:
[] Certification under 37 CFR 1.97(e), or
[] a $180.00 fee under 37 CFR 1.17(p), or
(After the CFR 1.97(b) time period, but before final action or notice of allowance, whichever occurs first.)

[] under 37 CFR 1.97(d) together with either a:
[] Certification under 37 CFR 1.97(e), and
[] a petition under 37 CFR 1.97(d)(2)(ii), and
[] a $130.00 petition fee set forth in 37 CFR §117(i)(1).
(Filed after final action or notice of allowance, whichever occurs first, but before payment of the issue fee.)

Applicant(s) submits herewith Form PTO 1449-Information Disclosure Citation together with copies of patents, publications or other information of which applicant(s) is aware, which applicant(s) believe(s) may be material to the examination of this application and for which there may be a duty to disclose in accordance with 37 CFR 1.56.

The relevance of the attached references is that this is the closest art of which applicant(s) is aware.

Applicant(s) submits that the above references taken alone or in combination neither anticipate nor render obvious the present invention. Consideration of the foregoing in relation to this application is respectfully requested.

Respectfully submitted,

Jim Zegeer

Jim Zegeer, Reg. No. 18,957
Attorney for Applicant(s)

Attachments:
Form PTO-1449 and cited references

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801 North Pitt Street
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Date: March 5, 2004

In the event this paper is deemed not timely filed, the applicant hereby petitions for an appropriate extension of time. The fee for this extension may be charged to Deposit Account No. 26-0090 along with any other additional fees which may be required with respect to this paper.

FORM PTO-1449 (MODIFIED) U.S. Department of Commerce Patent and Trademark Office

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use several sheets if necessary)

ATTY. DOCKET NO.	SERIAL NO.
3465-Z	10/712,104
APPLICANT: Peter Rabinovitch	
FILING DATE: November 14, 2003	GROUP: 1058

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc.)

	1.	Kohler et al, "The Click Modular Router", Laboratory for Computer Science, Massachusetts Institute of Technology, Date: 2000, pages 1-34.
	2.	Kohler, "The Click Modular Router", Submitted to the Department of Electrical Engineering and Computer Science in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the Massachusetts Institute of Technology, February 2001 (pages 1-127).
	3.	Cecchet, SciFS TECHNICAL & PRACTICAL GUIDE, Release 26, INRIA Rhone-Alpes SIRAC Laboratory (Pages 1-73), http://sci-serv.inrialpes.fr
	4.	Cecchet, "What is SciFS?", SciFS: A Distributed Shared Virtual Memory for SCI Cluster", http://sci-serv.inrialpes.fr/SciOS/whatis_scios.html (2 sheets).
	5.	Gilbert et al, "Scalable Routing Through Clusters", Department of Computer Science, Duke University, Durham, N.C., Published on the Internet at http://www.cs.duke.edu/~marty/cbr/ (5 sheets), 1999-12-15
	6.	Appenzeller et al, "Can Google Route?", Q2/2002 (21 sheets)
	7.	Chen et al, "Flexible Control of Parallelism in a Multiprocessor PC Router", published in the Proceedings of the USENIX 2001 Annual Technical Conference, June 2001 (pages 1-14).

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation is considered, draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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Atty. Docket No.: 3465-Z

UTILITY PATENT APPLICATION TRANSMITTAL
(Only for new nonprovisional applications under 37 C.F.R. §1.53(b))

Mail Stop PATENT APPLICATION
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Transmitted herewith for filing is the patent application of:

INVENTOR(S): Peter Rabinovitch (Kanata, Ontario, Canada)

TITLE: **Software Configurable Cluster-Based Router Using Heterogeneous Nodes as Cluster Nodes**

1. [X] Specification of 38 pages.
   [X] Claims, 36 in number.
   [X] Abstract.
2. [X] Drawings. Total Sheets: 8
3. [X] Oath or Declaration.
   a. [X] Newly executed (original or copy)
   b. [] Copy from prior application (37 CFR 1.63(d))
   (for continuation/divisional with Box 5 completed)

   i. [] DELETION OF INVENTOR(S)
   Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
4. [] Application Data Sheet. See 37 CFR 1.76.

5a. [] **If a CONTINUING APPLICATION**, check appropriate box and supply the requisite information below and in a preliminary amendment, or in an Application Data Sheet under 37 CFR 1.76:

[] Continuation [] Divisional [] Continuation-in-part (CIP):
of prior application Serial No.: _____
Prior application information: Group Art Unit: Examiner:

For: CONTINUATION OR DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 3b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application part.

5b. [] The present application is a nonprovisional application based on Provisional Application Serial No. _____ filed _____.

6. [] Applicant claims small entity status. (see 37 CFR 1.27)

7. [X] An assignment of the invention to: Alcatel and Recordation Form Cover Sheet with fee authorization.

8. [] Applicant claims the priority of corresponding application No. _____ filed _____.

9. [] Preliminary Amendment

10. [] Information Disclosure Statement (IDS) PTO-1449
[] Copies of IDS Citations.

11. [X] Return Receipt Postcard (MPEP 503)

12. [] Other:

13. [X] The filing fee has been calculated as shown below:

For	No. Filed	Basic	No. Extra	Rate $	Calculations
Total Claims	36	20	16	$ 18.00	$ 288.00
Indep. Claims	3	3	0	$ 86.00	$ .00
[ ] Multiple Dependent Claims				$290.00	$
BASIC FEE					$ 770.00
TOTAL OF ABOVE CALCULATIONS					$1,058.00
[] Reduction by 1/2 For Filing By Small Entity					$
TOTAL FILING FEE					$1,058.00
[X] Fee For Recording of Assignment ($40.00)					$ 40.00
TOTAL OF FILING AND ASSIGNMENT RECORDING FEES					$1,098.00

14. [X] A check in the amount of $ 1,058.00 to cover the Filing Fee is enclosed. If no check is enclosed and a fee is due in connection with this communication or if the check enclosed is insufficient, the Commissioner is authorized to charge any fee or additional fee due (or credit any overpayment) in connection with this communication, or at any time during the pendency of this application, to Deposit Account No. 26-0090.

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INVENTOR(S): Peter Rabinovitch (Kanata, Ontario, Canada)

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Prior application information: Group Art Unit: Examiner:

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Respectfully submitted,

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Attorney for Applicants

Date: November 14, 2003

Software Configurable Cluster-Based Router using Heterogeneous Nodes as Cluster Nodes

Field of the invention

[01] The invention relates to routing packets in packet-switched communication networks, and in particular to methods and apparatus for distributed routing response determination.

Background of the invention

[02] In the field of packet-switched communications, transported content is conveyed between source and destination communications network nodes in accordance with a store-and-forward discipline. The content to be transported is segmented, and each content segment is encapsulated in a packet by adding headers and trailers. Each packet is transmitted by the source network node into an associated communications network over communication links interconnecting communications network nodes. At each node, a packet is received, stored (buffered) while awaiting a packet processing response, and later forwarded over a subsequent interconnecting link towards the intended destination network node in accordance with: a destination node specification held in the packet header, and forwarding specifications provided via the packet processing response.

[03] Packet processing responses include, but are not limited to: switching, routing, traffic classification, traffic/content filtering, traffic shaping, content/traffic encapsulation, content encryption/decryption, etc. packet processing responses. A switching response in the context of a network node processing a particular received packet, specifies that the packet is to be forwarded via a particular output port of the subject network node. A routing response relates to a switching response determined based on a group of

routing criteria. The routing criteria may include, but are not limited to: communication link states, service level specifications, traffic classification, source/destination network node specification, time-of-day, congestion conditions, etc.

[04] One of the benefits of the store-and-forward discipline employed in conveying packets in packet-switched communication networks, stems from an ability of packet-switched networks to route packets around failed/congested communications network infrastructure, diminishing an otherwise need for a redundant communication network infrastructure, to reliably transport packets between source and destination network nodes.

[05] One of the drawbacks of the store-and-forward discipline employed in conveying packets in packet-switched communication networks, stems from delays incurred in obtaining packet processing responses – probably the most notable being the routing response delay which is for the most part non-deterministic. Additional non-deterministic delays are incurred if packets are subject to special treatment in providing packet processing responses such as, but not limited to: billing, encryption/decryption, video processing, authentication, directory services, network management functions, etc.

[06] Single unit, dedicated, hardware implemented router communication network nodes have been developed and deployed with various levels of success. Single unit, packet-switching communications network nodes implementing virtual routers have also been developed and deployed with various levels of success. However content transport capacity over interconnecting links, known as transport bandwidth, continues to increase at exponential rates, as well component miniaturization has enabled the aggregation of large amounts of packet traffic into such dedicated single unit router nodes. A lot of research and development has been, and is being, undertaken in respect of packet router network node design, which has lead to special purpose solutions typically addressing specific packet processing issues

and/or to support specific services via dedicated (router units) equipment. Router development costs are incurred in designing and validating the routing functionality, as well in designing and validating the special purpose, dedicated, router node hardware. Typically, the more functionality is desired to be provided by a particular router hardware implementation, the more prohibitive the development and validation costs are.

[07] Deploying single unit, dedicated, hardware implemented routers has always exposed a service provider operating thereof to technology change risks typically associated with new services. To some extent the single unit, dedicated, hardware implemented routers may be upgraded with new software and installed interface cards may be replaced with new more advanced interface cards supporting the new services. However, such attempts are typically limited as the original design thereof took advantages of all and any resources provided by the core hardware implementation. Therefore, the performance thereof in respect of new services is less than satisfactory.

[08] The single unit, dedicated, hardware implemented routers have evolved from computer-host-type network nodes. The relatively large expense associated with the development and deployment of single unit, special purpose, dedicated, hardware implemented routers has caused researchers to reconsider computer-host-type router implementations as personal computer equipment costs have decreased relative to the computing capability provided. The intent is to leverage readily available personal-computer hardware, which has also undergone separate intense development and standardization, to provide routing functionality comparable to hardware implemented router nodes. Returning to computer-host-type router solutions is in some ways considered a step back, because computer-host router implementations are software-based router implementations lacking packet processing response time guarantees, whereas dedicated router (equipment) nodes tend to implement the routing functionality in hardware which provides bound packet processing response times.

[09] FIG. 1 is a generic functional block diagram showing a legacy Personal Computer (PC) software-based router implementation. The legacy PC router implementation 100, which executes on an operating system platform 102 such as, but not limited to, Linux, includes software-implemented routing functionality, such as, but not limited to: packet filtering 110, packet header modification 112, packet queuing 114, scheduling 116, etc. The routing behavior of the legacy PC router 100 can be re-configured by re-coding the desired router functionality (110 – 116). Typically legacy PC router implementations 100 execute optimized special-purpose code to effect routing. While special-purpose code provides some efficiencies in providing routing responses, such solutions are not necessarily optimal under all conditions and typically lead to proprietary implementations addressing particular service deployments. Over-optimization leads to inflexible and expensive to maintain solutions.

[10] Improvements towards an improved PC-based router implementation includes the configurable Click router framework project at the Massachusetts Institute of Technology, U.S.A., a description of which can be found at http://www.pdocs.lcs.mit.edu/click/. Various developers have contributed to the development of the Click router framework including: Eddie Kohler (Ph.D. thesis student), Professor M. Frans Kaashoek and Professor Robert Morris, Benjie Chen, and John Jannotti.

[11] The Click router framework development started as an investigation into possible routing response processing improvements achievable by codifying discrete router functional blocks which, via a high level router description language, could be combined to implement (PC-based) router functionality at reduced router code maintenance overheads. FIG. 2 shows an exemplary prior art Click router configuration 200 implementing an experimental Internet Protocol (IP) router, the configuration 200 specifying discrete router functional blocks and packet processing flows defined between the discrete router functional blocks.

[12] Various levels of success were attained, including the realization that, in order to achieve superior packet throughput through a single off the shelf PC-based router, running a typical operating system, a closer coupling between the operating system, router software (Click in the MIT investigation), and the Network Interface Cards (NIC) (physical ports) was necessary. The typical interrupt handling technique ubiquitously used by network interface cards to report receiving a packet, and to announce availability to transmit a packet, was replaced by a polling technique to eliminate "receive livelock" conditions. It was found that using poling techniques, minimum-sized packet throughput increased fourfold. Minimum-sized packets are the most demanding of all types of packets when it comes to providing a processing response, as PC central processor resources are consumed in proportion to the number of packets processed not in proportion to the content bandwidth conveyed. The content bandwidth conveyed is ultimately limited by the bandwidth of the PC bus. Statistically however, the median packet size is relatively small in a typical use environment.

[13] Other results of the MIT Click investigation, include the definition of only sixteen generic discrete functional router blocks as a framework for implementing comprehensive packet processing responses – other specific functional router blocks being derived from the sixteen generic functional router blocks. In providing packet processing responses, the prior art typically concentrates on queuing disciplines and queue service disciplines. In the prior art, each routing function (filter 110, process 112, queue 114, schedule 116) contended for CPU time and cache. The Click investigation, however, looked into potential improvements achievable by prioritizing packet processing flows within a single PC-based router, and found that improvements may be benefited from careful allocation of CPU processing resources to packet processing flows which reduced CPU cache misses.

[14] Further results of the MIT Click investigation, include the adaptation of the Click router framework software code to operate on a multi-processor-

single-PC-based platform. The investigation continued toward prioritizing packet processing flows seeking benefits from careful allocation of the processing resources of all CPUs of the multiple-processor-PC platform to packet processing flows. CPU allocation to port-related packet processing flows seemed to provide best results by leveraging parallel processing over the multitude of processors (a maximum of 4 CPUs per PC-based router were employed in the investigation). However, it was found that one of the most detrimental of overheads were cache misses whose minimization correlated with increased packet processing throughput.

[15] However, the sharing of a single data bus between the multiple processors of the single-PC router implementation represented a limitation as, during periods of high packet throughput, the multiple CPUs contend for the single data bus. Therefore, implementing large capacity routers in accordance with the MIT Click investigation is difficult and/or very expensive to achieve because a very fast PC computing platform is required. This is due to the fact that the Click routing framework design is based on employing a single PC platform, and hence its performance is ultimately limited by the speed of the PC platform.

[16] In the field of distributed computing there is a current push to achieve network computing. Recent developments include the Scalable Coherent Interface (SCI) initiative which focuses on using new high bandwidth and low latency memory-mapped networks to build high performance cluster computing servers. The work in progress includes SCIOS, published on the Internet at http://sci-serv.inrialpes.fr/SciOS/whatis_scios.html, (contributor: Mr. Emmanuel Cecchet, France), which is an operating system module for the Linux operating system kernel offering services for managing resources in a cluster of Linux network nodes interconnected in an SCI network. The work in progress also includes SCIFS, published on the Internet at http://sci-serv.inrialpes.fr/SciFS/whatis_scifs.html, which is a file system module for the

Linux kernel offering services for implementing a distributed shared virtual memory, built on top of SCIOS, using a memory mapped file concept.

[17] The success of distributed computing towards achieving network computing, including the SCIOS/SCIFS initiative, hinges on the type of computation necessary to solve a problem. Network computing provides computation efficiencies, if the necessary work to solve the problem can be divided into discrete and independent work units, such that the processing of each work unit has a minimal to no influence on the processing of other work units. A successful network computing implementation is the SETI@Home project where processing each work unit involves determining self correlation between recorded signals in a single work unit.

[18] Investigations into distributed routing must take into account the issues pointed out by the Click initiative, that of packet processing flows traversing multiple routing functional blocks. The single PC-platform-based Click router framework investigation does not address network computing implementation issues and it is difficult to envision how, on their own, the results of the Click router framework investigation could be employed directly to provide distributed routing.

[19] A prior art attempt towards distributed routing was made by Martin Gilbert, Richard Kisley, Prachi Thakar of Duke University, U.S.A., published on the Internet at http://www.cs.duke.edu/~marty/cbr/, entitled "Scalable Routing Through Clusters". Gilbert et al. employed an experimental setup having two interconnected but otherwise independent PC-based routers.

[20] Further, Gilbert et al. found that, packets which cannot be received and sent from the same entry router node in the cluster router, must be forwarded from the entry router node over an intra-connection network to the exit router node, from where the packets are forwarded into an associated external communications network.

[21] Gilbert et al. realized that, for a cluster of PC-based routers to operate as a "single" router, it is was necessary for the Time-To-Live (TTL) packet header value to be decremented only once by exit nodes in the cluster. Gilbert et al. used a packet tagging technique and packet TTL decrement suppression code to prevent premature packet TTL decrements. The proposed solution actually introduced a problem: low TTL value packets are processed through the router cluster (in the Gilbert et al. implementation by both PC-based clusters) only to be dropped by exit cluster node, the corresponding Internet Control Message Protocol (ICMP) messages being sent from the exit router node and routed back through the entry router cluster (2 PC routers) towards the source. The proposed solution was extended to identify packets bearing low packet TTL values for immediate processing, at entry nodes in the cluster, rather than processing these packets through the cluster.

[22] To implement the intra-connection network, Gilbert et al. found it necessary to employ an additional lightweight protocol and a hierarchical naming scheme for router nodes in the cluster. The proposed solution was not without problems, of which Gilbert et al. identified: a routing overhead consisting of additional routing messages which needed to be exchanged in the cluster to propagate routing information related to external and internal changes to the cluster; extra protocol stack handling due to packets traversing several router nodes which involved examining each packet being processed at the IP layer to determine correct forwarding; and bandwidth reservation in the intra-connection network had to take into account the internal overhead. Although recognized as not ideal, Gilbert et al. propose employing statically-coded routing at each router node in the cluster to address the route-information sharing problem. Gilbert et al. state that "the ideal solution would be that the intra-connection network is completely transparent", and provide only a characterization stressing that: "[as the number of router nodes in the cluster increases], the latency associated with the extra protocol translation and physical link traversal on the intra-connection network will limit end-to-end throughput." Gilbert et al. call for employing, perhaps future faster packet

transport technologies to alleviate these issues in order to achieve the stated goals of their presented solution.

[23] Yet another prior art investigation into distributed routing is presented in FIG. 3 which shows an architecture referred to as a cluster-based router (CbR). The 4x4 cluster-based router 300 shown is comprised of four 2x2 router modules 310. Each of the routing modules 310 is implemented on a PC computing platform having gigabit Ethernet (1 GE), or similar, high speed interfaces 320. The 2x2 router modules 310 are interconnected in a manner that forms a non-blocking 4x4 routing architecture. Different sizes and arrangements of router modules 310 are possible to form different sized router clusters 300. Furthermore, a hierarchy of cluster-based routers 300 can be used to form even larger cluster-based routers. For example, a 16x16 CbR could be created from four of the 4x4 cluster-based routers 300 shown in FIG. 3. General details of this prior art proposal used to be found on the Internet at http://www.stanford.edu/class/ee384y/, but the details are no longer published.

[24] The CbR router 300 lacks flexibility in configuring thereof to address specific routing issues, and changes in routing functionality require new hardware or new code development. Moreover, it is apparent that a scalability issue exists as the number of 2x2 router modules 310 increases as $O(N^2)$ for an O(N) growth in ports.

[25] Another prior art investigation into the feasibility of using a Clos network to implement distributed routing is entitled "Can Google Route?" and was presented by Guido Appenzeller and Mathew Holliman. The Clos network architecture is proposed because such a design is non-blocking.

[26] Appenzeller and Holliman show a dramatic increase in cost-per-gigabit with total throughput for single unit dedicated routers. Appenzeller and Holliman show that using Clos-network-type router clusters is only more economical than single unit dedicated hardware routers for implementations

involving very large numbers of ports. In general Clos networks employ a hierarchy of nodes: edge and core. Edge nodes exchange packets with external communications networks while core nodes do not, which is why, in general, switching N inputs to N outputs requires $(N/4)\log_4 N\ (1.5)^{\log_2\log_4 N}$ which increases $O((N/4)\log_4 N)$ with N.

[27] Further Appenzeller and Holliman confirm the results of the MIT Click investigation, in that the use of PC bus interrupt techniques represents a packet throughput bottleneck and propose aggregating short packets. To implement the proposal, the network interface cards employed must have large buffers operating at line speed which negatively impacts the cost of such a deployment. While the MIT Click investigation proposes to use optimized network interface card polling techniques, Appenzeller and Holliman propose a less optimum solution of using Linux in halted mode.

[28] In view of the aforementioned shortcomings of the prior art investigations, what is desired is a low-cost router that is flexible, and scalable in routing capacity and port count.

Summary of the invention

[29] In accordance with an aspect of the invention, a cluster-based router is provided. The cluster router includes a plurality of interconnected router cluster nodes, the routing capacity of the cluster router increasing substantially O(N) with the number N of router cluster nodes in the cluster router. Each router cluster node has a group of cluster router external links enabling packet exchange with a plurality of external communication network nodes. At least one special purpose cluster node provides special packet processing functionality in the cluster router. A plurality of cluster router internal links interconnect router cluster nodes forming an intra-connection network ensuring a high path diversity in providing resiliency to failures. And, each router cluster node operates in accordance with a provisioned router-cluster-node-

centric configuration to effect distributed routing of the conveyed packets. Employing the at least one special purpose cluster node provides a reduction in the development, validation, deployment, and re-configuration of the cluster router.

[30] In accordance with another aspect of the invention, the at least one special purpose cluster node providing special packet processing functionality further comprises one of: a specially coded personal computer platform, a personal computer platform having designed hardware characteristics in providing specific functionality, dedicated hardware implemented equipment designed to provide an enhancement in providing special packet processing functionality, and a router cluster node further coded to provide special packet processing functionality.

[31] In accordance with a further aspect of the invention, the intra-connection network further comprises an n dimensional toroidal topology. 2*n internal links interconnect each router cluster node with 2*n adjacent neighboring router cluster nodes; the routing capacity of the cluster router being increased substantially linearly by adding an n-1 dimensional slice of router cluster nodes to the cluster router.

[32] In accordance with a further aspect of the invention, the cluster router further includes: at least one management node; and a plurality of management links interconnecting the at least one management node with the plurality of router cluster nodes. The plurality of management links enable one of out-of-band: configuration deployment to each router cluster node, router cluster node initialization, and reporting functionality. Employing the plurality of management links, reduces an in-band cluster router management overhead.

[33] In accordance with a further aspect of the invention, the special purpose cluster node is associated with the management node; the special functionality provided being available one-hop-away from each router cluster node.

[34] In accordance with a further aspect of the invention, the plurality of management links from a one of a star and bus topology.

[35] In accordance with a further aspect of the invention, the cluster router further includes an internal addressing process dynamically determining router cluster node addressing.

[36] In accordance with a further aspect of the invention, the cluster router further includes an external addressing process dynamically determining a router cluster address.

[37] In accordance with a further aspect of the invention, means are provided for distributing to each router cluster node information regarding availability and addressing information regarding special purpose cluster nodes.

[38] In accordance with a further aspect of the invention, methods of detecting special purpose cluster nodes providing special packet processing functionality are provided.

[39] In accordance with a further aspect of the invention, a router cluster node of a plurality of router cluster nodes interconnected in a cluster router is provided. The router cluster node includes a plurality of cluster router internal interconnecting links connected thereto, the internal interconnecting links enabling the exchange of packets with adjacent cluster nodes in the cluster router. At least one cluster router external link connected thereto, the at least one external link enabling exchange of packets between external communications network nodes and the cluster router. And, a router-cluster-node-centric configuration to effect distributed routing of the conveyed packets. The equivalency between router cluster nodes in the cluster router providing a scalable router.

[40] In accordance with a further aspect of the invention, the router cluster node further provides special packet processing functionality as a special purpose cluster node.

[41] In accordance with a further aspect of the invention, a router-cluster-node-centric configuration is provided. The router-cluster-node-centric configuration enables the provision of a distributed packet routing response in a cluster router having a plurality of router cluster nodes. The configuration specifies a plurality of routing functional blocks; and at least one router-cluster-node-centric packet processing flow, via the plurality of routing functional blocks. The routing of packets received at the cluster router is effected employing one of a single router cluster node and a group of router cluster nodes.

[42] In accordance with a further aspect of the invention, the router-cluster-node-centric configuration includes: an entry-and-routing processing packet processing flow specification; a transit packet processing flow specification; and an exit packet processing packet processing flow specification. The packet processing flow specifications enable a received packet to undergo entry-and-routing processing at an entry router cluster node, optionally transit via at least one intermediary router cluster node, and undergo exit processing at an exit router cluster node.

[43] In accordance with a further aspect of the invention, the router-cluster-node-centric configuration employs a tag conveyed with each packet within the cluster router infrastructure. The tag holds specifiers tracking packet processing within the cluster router.

[44] In accordance with a further aspect of the invention, packets being processed are tagged with a tag specifying that a packet is undergoing one of a routing processing and a special packet processing functionality.

[45] In accordance with a further aspect of the invention, each tag holds a tag time-to-live specification decremented while the associate packet propagates via router cluster nodes in the cluster. The packet is discarded when the time-to-live specification is zero and the packet has not reached a corresponding exit router cluster node thereby reducing transport overheads.

[46] In accordance with a further aspect of the invention, a router-cluster-node-centric configuration enabling the provision of a distributed packet routing response in a cluster router having a plurality of router cluster nodes and at least one special purpose cluster node is provided. The configuration includes at least one routing functional block determining a need for special functionality in respect of processing a packet. At least one router-cluster-node-centric packet processing flow effects forwarding of the packet to a special purpose cluster node for processing.

[47] In accordance with a further aspect of the invention, the at least one router-cluster-node-centric packet processing flow further specifies one of: storing a copy of the packet header and a corresponding tag in an optional header of the packet; and storing information about the packet in a storage structure for the purposes of continuing packet processing in accordance with the router-cluster-node-centric configuration.

[48] In accordance with yet another aspect of the invention, the at least one cluster-node-centric packet processing flow further specifies employing addressing information stored in the packet header in forwarding the packet requiring special processing towards a special purpose cluster node.

[49] Advantages are derived from: a configurable, and scalable cluster router design providing a re-configurable high routing capacity using cost effective stock PC hardware; from the intra-connection network which provides a high degree of diversity ensuring resilience to equipment failure; from the use of a star topology with respect to management links which reduces management overheads in the intra-connection network; and from the ability to forward packets to designated special purpose router cluster nodes optimized to provide specific packet processing functionality.

Brief description of the drawings

[50] The features and advantages of the invention will become more apparent from the following detailed description of the preferred embodiments with reference to the attached diagrams wherein:

FIG. 1 is a schematic diagram showing elements implementing a prior art personal computer executing packet routing software code;

FIG. 2 is a schematic diagram showing packet processing flows directing packets between router functional blocks in accordance with a Click configuration implementing an exemplary IP router;

FIG. 3 is a schematic diagram showing a prior art non-blocking cluster-based router architecture;

FIG. 4 A and B are schematic diagrams showing, in accordance with exemplary implementations of an exemplary embodiment of the invention, cluster-based router architectures having three dimensional and seven dimensional interconnectivity respectively;

FIG. 5 A, B, and C are schematic flow diagrams showing exemplary packet processing flows and routing functional blocks providing packet routing in accordance with an exemplary embodiment of the invention; and

FIG. 6 is another schematic flow diagram showing exemplary packet processing flows and routing functional blocks providing packet routing in accordance with the exemplary embodiment of the invention.

[51] It will be noted that in the attached diagrams like features bear similar labels.

Detailed description of the embodiments

[52] A solution is proposed wherein multiple routing elements are configured to operate as a single routing entity seeking cost reductions and improvements in scalability, and easy re-configurability. Improvements are sought in performing certain functions such as, but not limited to: billing, payload decryption/encryption, decoding/encoding content, network management, video stream processing, authentication, directory services, etc. While cost overheads may be reduced by employing inexpensive off-the-shelf equipment, provisioning special functionality may benefit from the use of specialized equipment when a favorable efficiency-cost ratio may be taken advantage of in respect of specific packet processing functionality.

[53] In accordance with an exemplary embodiment of the invention, FIG. 4A shows an exemplary cluster-based router implementation 400 which includes a 3 x 4 x 3 (cluster) arrangement of PC-based router cluster nodes 402 interconnected in accordance with a toroidal topology. Selected cluster router nodes 406 represent special purpose router cluster nodes providing special packet processing responses. If special purpose router cluster nodes 406 include off-the-shelf equipment having superior capabilities in respect of special packet processing functionality; a reduction in the development, validation, and deployment costs of the proposed solution may be provided. Dedicated, single unit, hardware implemented packet processing equipment may employed such as, but not limited to: billing systems, statistics generators, directories, databases, etc. Such a hybrid cluster router 400 would therefore benefit from optimized hardware implemented packet processing functionality of the special purpose router cluster nodes 406 while the shortcomings (cost, flexibility, re-configuration, etc.) of such dedicated, single unit, hardware implemented equipment are mitigated by employing the PC-based router cluster nodes 402.

[54] The invention is not limited to the number of router cluster nodes, nor to the topology shown. An arbitrary number of router cluster nodes 402 (typically a large number) and 406 (typically a small number) may be interconnected in

accordance with various topologies without limiting the invention. The choice of the number of router cluster nodes 402/406 is chosen to obtain a required packet response processing (routing) capacity, while the chosen topology employed is a balance between advantages and disadvantages including, but not limited to: cost, complexity, delay, blocking probability, etc. which may be dependent on the routing capacity.

[55] In accordance with the exemplary embodiment shown, the individual router cluster nodes 402(/406) are arranged in x, y, and z slices; and each router cluster node 402(/406) is physically connected 404 to adjacent router cluster nodes 402 in the x, y, and z directions. In is pointed out that only two z-toroidal inter-connections are shown in order to improve clarity of FIG. 4A, however every router cluster node 402 participates in a z-toroid of which (exemplary) there are twelve in total. The toroidal interconnections 404 shown in FIG. 4A, implement a dedicated cluster intra-connection network. In order to simplify the presentation of the relevant concepts, toroidal interconnections 404 will be referred to herein as internal interconnection links 404 connected to internal ports without limiting the invention thereto. Each internal interconnecting link 404 between any two router cluster nodes 402(/406) may either be a unidirectional or a bi-directional link without limiting the invention.

[56] Wraparound internal interconnection links 404 complete toroidal interconnectivity ensuring that every router cluster node 402(/406) has, in accordance with the exemplary toroidal topology employed, six adjacent router cluster nodes 402(/406) to ensure path diversity. Should any router cluster node 402(/406) or internal interconnecting link 404 fail, the toroidal topology ensures that other paths between any source and destination router cluster nodes 402(/406) exist.

[57] In accordance with the exemplary embodiment of the invention, employing toroidal interconnectivity between the router cluster nodes 402 enables all router cluster nodes 402 to be equivalent. In particular the toroidal

topology does not dictate which router cluster nodes 402 are edge or core router cluster nodes 402. Such designations may of course be made logically, if necessary, and may only apply to a specific service being provisioned. However, depending on each particular implementation, such designations may bring about a management overhead. The equivalency between router cluster nodes 402 enables each router cluster node 402 to have external physical links (schematically shown as patch bays) providing physical connectivity to communications network(s) in which the cluster router 400 participates. Therefore, in accordance with the exemplary embodiment of the invention, each router cluster node 402 may act as an entry, core, and/or exit router cluster node 402 with respect to the packet traffic processed by the cluster router 400.

[58] The router cluster node equivalency, provided via the toroidal topology, provides a highly scalable packet routing capacity and port count increasing monotonically ~O(N) with the number N of router cluster nodes 402 in the cluster router 400 assuming that the number of special purpose router cluster nodes 406 in the cluster router 400 is relatively small. Additional capacity may be added typically by adding another x, y, or z slice (n-1 dimensional plane) of router cluster nodes 402 without requiring replacement or expansion of the existing infrastructure.

[59] The cluster router 400 may be controlled by management software allowing an operator to configure the behavior of each router cluster node 402 and therefore of the entire cluster router 400 via a software-based specification language with appropriately coded routing functionality blocks (a modified version of the Click routing framework being an example) to affect packet routing in accordance with the exemplary embodiment of the invention.

[60] In accordance with an exemplary implementation of the exemplary embodiment of the invention, at least one additional node 410, shown in FIG. 4A, may act as a cluster-remote management node responsible for: startup,

initial configuration of each router cluster node 402 in the cluster router 400, lookup table synchronization, monitoring, performance reporting, etc.

[61] Special purpose cluster router nodes 406 may also be managed via associated node management means, described elsewhere. Management nodes 410 may also act as management entities to special purpose cluster nodes 406 without limiting the invention thereto.

[62] In accordance with the exemplary toroidal topology of the exemplary embodiment of the invention, should a number of the router cluster nodes 402 or a number of interconnecting links 404 fail, the cluster router 400 will continue to route (process) packets therethrough, perhaps, but not necessarily, at a reduced routing capacity until the failed infrastructure is brought back on-line which represents an improvement over dedicated single unit routing equipment. Whether packet (processing) routing capacity is affected by a particular infrastructure failure, is dependent on actual packet traffic patterns within the cluster router 400. However, as long as routing capacity and packet transport capacity is still available in the cluster router 400, the toroidal interconnectivity provides a possibility for work distribution over the remaining router cluster nodes 402.

[63] Failure of special purpose router cluster nodes 406, may be mitigated by employing redundant special purpose router cluster nodes 406, default special purpose packet response processing, relegation of special packet processing functionality to management nodes 410, etc.

[64] Due to the toroidal topology employed, the lattice of the cluster router 400 can be extended to multiple dimensions: rather than linking each router cluster node 402 only to neighbor router cluster nodes 402 in the x, y and z direction, each router cluster node 402 can be linked to 2*n neighbors in n dimensions. FIG. 4B shows exemplary 7-dimensional router cluster node 402/406 interconnectivity (external connectivity as shown in FIG. 4A). The additional interconnectivity provides: increased path diversity thereby

reducing blocking probability, reductions in the number of hops between entry and exit router cluster node 402 pairs, reductions in transmission delay, and provides the possibility for packet processing distribution away from congested router cluster nodes 402 (congestion mitigation). Theses advantages come at a cost of increased wiring, maintenance, packet processing distribution decision making, etc. complexity; and an increased cost of: a large number of cables, a correspondingly large number of network interface cards, PC motherboards adapted to interconnect with numerous network interface cards, multiported network interface cards, etc. Thus the choice of a specific interconnection density is a design choice to be made based on specific application environment requirements.

[65] In accordance with the exemplary implementation of the exemplary embodiment of the invention, cluster management software, if executing on cluster-remote management nodes 410, communicates with router cluster nodes 402(/406) via dedicated management links 412 ensuring that the cluster intra-connection network does not incur an in-band management overhead. If management functionality available via the management links 412 does not necessitate a high bandwidth, the cluster router 400 need not incur a high deployment cost overhead associated with the management links 412.

[66] In FIG. 4A, the management links 412 are shown to form a star topology between the cluster-remote management nodes 410 and the router cluster nodes 402(/406). No such limitation is implied in respect of the invention, a variety of other topologies may be employed including bus topologies. The star topology ensure the availability of management functionality one-hop-away from each router cluster node 402(/406 if managed by management nodes 410).

[67] While employing a bus topology provides native broadcast capabilities, particularly benefiting lookup table synchronization, without necessarily providing a change in the number of management links 412 when compared to the star topology; employing a bus topology exposes the cluster router 400 to a

collision overhead in the management links 412. The collision overhead may be mitigated by employing higher bandwidth infrastructure for the bus topology management links 412, or by employing multiple busses, both propositions adding significant costs to such implementations. Depending on the size of the cluster router 400, the benefits of the native broadcast capabilities in employing a bus topology may overweigh the cost incurred by the collision overhead. The actual implementation of the management network is therefore left to design choice.

[68] In accordance with an exemplary implementation, the management links 412 may be implemented as serial links. Serial links employ serial ports typically available directly on the motherboard of each PC router cluster node 402 reducing bus connector requirements imposed on the design of each PC motherboard. While the aggregation of all serial links at the management node may require aggregation equipment, such aggregation equipment exists and enjoys standardization.

[69] Special purpose router cluster nodes 406 may include dedicated single unit hardware implemented equipment providing enhanced packet response processing with respect to special functionality such as, but not limited to: billing, encryption, decryption, stream encoding/decoding, video stream processing, authentication, directory services, etc. Depending on the architecture of the special purpose router cluster node 406 equipment, there may be a mismatch between the number of physical ports available and the degree of interconnectivity in the cluster intra-connection network. If the number of internal interconnection links 404 connectable to each router cluster node in the cluster router 400 is larger then the number ports available at a special purpose router cluster node 406, then the mismatch may be mitigated by employing multiplexer/demultiplexer equipment; the choice of the number of special purpose router cluster nodes 406 and multiplexer/demultiplexer equipment being dependent on the bandwidth necessary in provisioning the special functionality at the special purpose router cluster nodes 406.

[70] In accordance with another implementation of the exemplary embodiment of the invention, shown in FIG. 4B, at least one router cluster node in (the lattice of) the cluster router 400 is designated as an in-cluster management node 410 providing management functionality either: on a dedicated basis 406 (the special functionality being cluster router management), in conjunction with providing routing functionality (402), or in conjunction with (other) special functionality (406). In case a failure is experienced by the router cluster node (402/406) designated as the primary management node 410, another router cluster node 402/406 may be designated as the "active" management node 410 on short order without requiring infrastructure modifications to the cluster router 400.

[71] In accordance with another exemplary implementation, management functionality employs in-band signaling and messaging incurring a small management overhead while the management functionality being a number of hops away from a large number of cluster router nodes 402(/406 if managed by management nodes 410).

[72] Depending on a particular implementation of the exemplary embodiment of the invention, special functionality nodes 406 may be associated with cluster-remote management nodes 410, as shown in FIG. 4A, or may be interconnected in the cluster router 400 as cluster router nodes 406 as mentioned above. In associating the special functionality nodes 406 with the cluster-remote management nodes 410, the management links 412 must have available adequate bandwidth. If a high bandwidth management link 412 were employed for each router cluster router node 402, special functionality would be provided "one-hop-away" from each router cluster node 402 determining a need for the special functionality in processing a packet.

[73] However, if the special functionality router cluster nodes 406 are interconnected in the lattice of the cluster router 400, then the larger the cluster router 400, the further in terms of hops the special functionality nodes 406

would be, on average, from the router cluster node 402 determining a need for the special functionality in processing a packet. The distance in terms of the number of hops between the router cluster node 402 determining the need for special functionality and the special functionality router cluster nodes 406 providing the special functionality, being insignificant if the packet processing cost in terms of a total transport delay along the cluster intra-connection network is much much smaller than packet response processing at the nodes 402, 406, and 410.

[74] In accordance with the exemplary embodiment of the invention, the same routing functional block definitions are provided to each router cluster node to ensure that each router cluster node is capable to perform every and any routing functionality necessary. Details regarding the necessary routing functionality blocks is provided herein below with reference to FIG. 5 and FIG. 6. In particular PC-based cluster router nodes 402 receive the routing functional block definitions and act accordingly.

[75] However, in-cluster special functionality router cluster nodes 406 may be dedicated special purpose single unit hardware equipment, and therefore may not be capable of receiving, interpreting, and/or acting in accordance with the distributed routing functional blocks. Nor would in-cluster special purpose router cluster node 406 be capable of receiving, interpreting and/or acting in accordance with a distributed cluster router configuration. For all intents and purposes, in-cluster special purpose router cluster nodes 406 act as if connected in a communications network of no particular significance between other (router cluster) nodes (402); the degree to which this is achieved being balanced against cluster router configuration complexity:

[76] In accordance with the exemplary embodiment of the invention, a cluster-node-centric router cluster node configuration, distributed in the router cluster 400, specifies cluster-node-centric packet processing flows within each router cluster node 402 such that each router cluster node 402 by itself, and/or

the aggregate of all router cluster nodes 402/406 in the cluster router 400 provide packet routing functionality. Details of exemplary cluster-router-node-centric configurations are provided herein below with respect to FIG. 5 and FIG. 6. In ensuring interoperability with special purpose router cluster nodes 406, cluster-node-centric cluster router node configurations must take into account the fact that special purpose cluster router nodes 406 cannot be counted on to be aware of, or be configured via, the distributed cluster-node-centric router cluster node configuration.

[77] In accordance with the exemplary embodiment of the invention, each router cluster node 402 is also provided with a list of special functionality provided via specific special purpose router cluster nodes 406. The list may include redundant entries. The list may also be updated on a regular and/or as needed basis. Each router cluster node 402 may further request an update from a management node 410.

[78] Alternatively special purpose router cluster nodes 406 providing special functionality may be discovered perhaps by employing a services discovery protocol such as, but not limited to: Lightweight Directory Access Protocol (LDAP), extended Domain Name Services (DNS), and/or mechanisms employed in respect of the Extensible Open Routing Platform (XORP) described in respective Requests For Comments RFCs 2671, 2782, 2307 and incorporated herein by reference.

[79] For easy understanding of the concepts presented herein and without limiting the invention thereto, router cluster node physical ports are designated as: internal ports, external ports, and loopback ports. Internal ports terminate cluster router internal interconnecting links 404 participating in the intra-connection network implementing the toroidal topology of the cluster router 400. External ports terminate cluster router external links to communication network nodes external to the cluster router 400 (see patch bays in FIG. 4A). The loopback ports enable each router cluster node 402 to provide all the

necessary and related routing functionality need to process a received packet especially when the packet is to be sent towards the intended destination via an external link associated to the same router cluster node 402 which received the packet.

[80] In order for the cluster router implementation presented herein to replace a single router, not only is it necessary for packets to be processed by the router cluster nodes 402/406 of the entire cluster router 400 as if they were processed by a single router, but the entire cluster router 400 must appear to external communications networks and nodes as a single communications network attached (router) entity. Adherence to the requirement is complicated by the fact that different external links are connected to different router cluster nodes 402 in the cluster router 400.

[81] An addressing scheme, perhaps as simple as using Media Access Control (MAC) addressing may be relied on. Internet Protocol addressing may also be used, however reliance on such use, as packets hop from router cluster node 402/406 to router cluster node 402/406, may lead to a lot of unnecessary protocol stack processing. In using MAC addressing to refer to each router cluster node 402/406, each physical port has a globally unique MAC address ascribed thereto during manufacturing thereof, the MAC address of a particular router cluster node 402/406 may be set to the lowest MAC address value of all of the physical ports associated therewith (or to the lowest MAC address of a multiplexer/demultiplexer). It may be necessary that only physical ports used to implement the cluster intra-connection network be considered in an internal router cluster node addressing scheme to ensure that packets do not spill out of the cluster router 400 prematurely while propagating between cluster router nodes 402. In order for the aggregate of router cluster nodes 402 to appear as a single router to external communications networks, the MAC address of the cluster router 400 may be set to the lowest MAC address of all router cluster node (ingress and egress) external ports (external addressing scheme).

[82] In accordance with an exemplary implementation of the exemplary embodiment of the invention, the MAC address of the cluster router 400 is determined by the router cluster nodes 402 in the cluster router 400 cooperatively. The invention is not limited to this particular method of determining the address of the cluster router 400. However, employing methods of dynamic internal cluster router MAC address determination, takes into account that the router cluster node 402 with the smallest MAC address may be removed and installed at another location in an associated communications network thus preventing packet misdirection.

[83] In accordance with another exemplary implementation of the exemplary embodiment of the invention, the external MAC address of the cluster router 400 may be determined by a management node 410. If the management node is used solely for management of the cluster router 400, then the MAC address of the management node 410 may be used as the MAC address of the entire cluster router 400. If a group of redundant management nodes are used, then the group of management nodes may collectively employ a dynamic external MAC address determination scheme which takes into account that any one of the management nodes 410 may fail or may be relocated in an associated communications network.

[84] In accordance with the exemplary embodiment of the invention, router cluster nodes 402 in the cluster router 400 may employ only a reduced protocol stack in implementing the cluster intra-connection network. If the cluster router 400 is exemplary employed for routing Internet Protocol (IP) packets, the router cluster nodes 402 may only implement Ethernet encapsulation in the cluster intra-connection network.

[85] Having received a routing response, a packet in transit towards the exit router cluster node 402, if unchecked, may circle around the redundant intra-connection network (404) forever introducing an uncontrollable transport bandwidth overhead.

[86] In accordance with the exemplary embodiment of the invention, each packet is tagged to identify the received packet as one having received a routing response or as one necessitating special functionality, and propagating through the cluster router 400 towards an intended router cluster node 402/406. A variety of tagging means may be employed including, but not limited to: using optional packet header, adding packet trailers, and/or encapsulating the received packet with additional (Ethernet) headers having cluster router relevance only. Upon arriving at a specified exit router cluster node 402, the tag is removed.

[87] In accordance with the exemplary embodiment of the invention, a TagTTL value is specified in the tag for each tagged packet, the TagTTL having cluster router 400 relevance only. An initial MaxTagTTL value would be set to an empirically determined value typically dependent on the size of the cluster router 400. The MaxTagTTL value must be set high enough to enable the packet to traverse the entire cluster router 400, yet the MaxTagTTL value must be set low enough to minimize packet transport overheads.

[88] In accordance with the exemplary embodiment of the invention, FIG. 5 A, B, and C show a flow diagram representative of a router-cluster-node-centric configuration disseminated to each router cluster node 402.

[89] FIG. 5A is a high level overview of the router-cluster-node-centric configuration 500 (and 600). In accordance with an exemplary implementation of the exemplary embodiment of the invention, the goal of determining a routing response for each received packet is divided into entry packet processing and routing response processing; special functionality processing; and exit packet processing.

[90] Each packet received via an external input port 502 is classified to determine which leg of the configuration 500 to subject the packet to. Newly received packets (received via an external input port 502) are directed to an entry packet processing leg, whereby the packet undergoes entry packet

processing and routing response processing. Subsequent to receiving the packet, the packet is tagged 540. A determination is made 700 as to whether pre-routing special packet processing is required, such as, but not limited to: decryption, decoding, billing, etc.

[91] If pre-routing special packet processing is required, an indication that the packet is undergoing special pre-routing processing is specified 702 in the tag; the entire packet header and tag are stored, without limiting the invention thereto, in a secondary optional header 704; the tag source and destination specifications are cleared; and source and destination specifications in the packet header are populated 706 with the MAC address of the router cluster node 402 which determined that the packet required special processing, and the MAC address of the special purpose router cluster node 406 providing the special functionality respectively. The TagTTL value is set 542 to the MaxTagTTL value. The packet is subsequently transmitted over one of the internal output ports 552 (or 554 as appropriate).

[92] Intermediary router cluster nodes 402, based on the fact that the tag specifies that the packet requires special processing, employ source and destination information specified in the packet header, not in the tag, to direct the packet towards the special function router cluster node 406 decrementing 574 the TagTTL in the process.

[93] The special function router cluster node 406 receives the packet and because the special function router cluster node 406 is not (expected to be) knowledgeable the existence of the cluster router 400 in which it participates, the special function router cluster node 406 simply provides the special functionality such as, but not limited to: decryption, decoding, billing, etc. On performing its function, the special function router cluster node 406 ignores the tag as the tag is implemented as an optional header extension, and also ignores the secondary optional header. On completing its function, the special function router cluster node 406, reverses the source and destination addressing

information in the packet header, not in the tag, and transmits the packet over an appropriate output port thereof.

[94] Having received special processing while the tag remains still intact, intermediary router cluster nodes 402, based on the fact that the tag still specifies that the packet requires special processing, employ the reversed source and destination information specified in the packet header, not in the tag, in forwarding the packet towards the router cluster node 402 which determined the need for special functionality. The TagTTL value is decremented 574 as the packet is forwarded in the cluster router 400.

[95] Ultimately, the router cluster node 402 which determined that the packet needed special processing, finds 710 itself as the destination, and makes a determination 700 whether the packet requires further pre-routing special processing. If further pre-routing special processing is required the process is repeated. Care must be taken to ensure that at least addressing information from the original packet header is saved at all times and that the packet header including the tag is reconciled with the saved version thereof. Depending on implementation, special processing may include modifying the regular packet header, since the original copy is kept, a regular packet header reconciliation must be performed as appropriate and specific to each implementation before routing response processing is performed.

[96] Alternatively, the original packet header may be stored in a data structure along with appropriate packet identification at the router cluster node 402 sending the packet for special processing, however in accordance with such an implementation additional storage resources must be provided and managed at each router cluster node 402 increasing resource utilization overheads associated therewith. Packet identification may be included in the tag. Storing the regular packet header in the secondary optional packet header increases the size of each packet and therefore incurs a bandwidth overhead in the cluster intra-connection network.

[97] Depending on the particular special processing required the bandwidth overhead may be reduced: Some forms of special packet processing such as billing may only require a copy of the actual packet header, without the payload, to be transmitted to the billing special purpose router cluster node 406 without returning anything from the billing special purpose router cluster node 406, thereby reducing resource utilization in the cluster intra-connection network.

[98] If no further pre-routing special packet processing is required 700, the packet receives a routing response 570 and is forwarded via (a cluster router external port 530,) an internal port 552 or the loopback port 554 as appropriate after the TagTTL value has been reset 542 to the MaxTagTTL value.

[99] Tagged packets propagate in the cluster router 400 lattice from router cluster node 402(/406) to router cluster node 402(/406) according to addressing information held in the tag towards the exit router cluster node 402 by following the transit leg of the configuration 500. The TagTTL value is decremented 574 along the way.

[100] The exit packet processing leg of the configuration 500 is typically followed upon receiving a packet via an cluster router internal port 556 or loopback port 554. As part of exit processing, a determination 720 is made as to whether the routed packet necessitates post-routing special packet processing, such as, but not limited to: encryption, encoding, etc.

[101] At the exit router cluster node 402 which determined that the packet requires post-routing special processing, an indication that the packet is undergoing special post-routing processing is specified 722 in the tag; and packet processing continues from step 704 as described above. The TagTTL value is set 542 to the MaxTagTTL value and the packet is subsequently transmitted over one of the internal output ports 552 (or 554 as appropriate).

[102] With the post-routing special processing complete (or not necessary), the tag is removed 582 and the packet TTL is decremented 584 before packet transmission via an external link. The packet is then switched to be forwarded via the appropriate external port 530.

[103] It was mentioned above that special packet processing may be provided by router cluster nodes 402 in conjunction with the provision of the routing response or packet forwarding specified in the router-cluster-node-centric specification. Details of an exemplary router-cluster-node-centric specification are provided following:

[104] FIG. 5B shows details of the entry packet processing and routing response provisioning leg. A packet is received at the cluster router 400 via an external link and a corresponding external physical port 502. The received packet is typically provided to a packet filtering (firewall) block 504 exemplary subjecting the received packet to packet acceptance rules. If the packet is not accepted, the packet is dropped.

[105] If the packet is accepted by the packet filtering block 504, the packet is forwarded to a decision block 506, which determines whether the packet is specifically destined for the subject router cluster node 402 currently processing the packet. If the packet is destined for the subject router cluster node 402, the packet is forwarded to the Operating System (OS), block 508 – in this case the router cluster node operating system. If the packet is not destined for the router cluster node 402, it is forwarded on to decision block 510.

[106] Decision block 510 determines whether the received packet is destined for the cluster router 400 proper. If the packet is destined for the cluster router 400, the packet is forwarded to a management port output queue block 512 and is eventually transmitted via a management output port 514 to a dedicated management node 410. If a router cluster node is designated as a management node 410, then the packet is forwarded via an appropriate cluster router internal port 552 towards the designated management node. If the packet is not

destined for the cluster router 400, in step 510, the packet is forwarded to decision block 520.

[107] Decision block 520 inspects the packet header to obtain the packet TTL value. If the packet TTL value is too low, the packet is not processed any further with respect to providing a routing response. An ICMP Error "TTL Expired" message is formulated for the packet by block 524. The source and destination network node addressing specifications of the received packet are extracted and reversed, and the packet conveying the ICMP message is provided to the exit packet processing leg. As will be described with reference to FIG. 5C, the packet is placed on an output port queue 528 (lowest priority) of the external output port 530 corresponding to the input port 502 via which the packet was received. If the decision block 520 does not find a low packet TTL value, the packet is forwarded on.

[108] The packet is typically (but not necessarily) subjected to a packet acceptance rate control block 536. The packet is further processed through various other entry packet processing blocks, for example to check the integrity of the packet header, to remove a number of bytes, etc, which will be omitted from being shown for brevity of the description of the exemplary embodiment presented herein. A person skilled in the art would specify a sequence of entry packet processing blocks necessary to support the services provided. Each such block typically performs a combination of: accepting the packet, modifying the packet header, dropping the packet with or without associated processing such as sending a message back, etc.

[109] Special packet processing is performed as described with respect to FIG. 5A and tagged 540. The tag includes a data structure conveyed with the packet in an optional packet header. The data structure holds specifiers employed by router cluster nodes 402 to track the packet while in transit within the cluster router 400.

[110] The packet is classified by classifier block 564 in accordance with the packet's priority for preferential processing and stored in a priority queue 566. Packets are scheduled for routing response processing by scheduler block 568 which preferentially selects high priority packets to be routed thereby enforcing quality of service guarantees. A route lookup is performed by lookup block 570.

[111] Routing response processing results in the packet header being updated with next hop information including a network address of a next communications network node towards which the packet is to be conveyed upon leaving the cluster router 400, as well the tag information is updated with router cluster node addressing information (a MAC address specification) of the corresponding exit router cluster node 402.

[112] Having received a routing response, decision block 571 determines whether the determined next hop network address is connected locally with respect to the subject router cluster node 402. If the network node corresponding to the next hop network address is connected to a port of to the subject router cluster node 402, then the packet is provided to the exit packet processing leg.

[113] If the network node corresponding to the determined next hop address is not know locally, a TagTTL specifier is populated with a MaxTagTTL value by block 542. It is worth re-emphasizing that the TagTTL value is independent of the packet TTL value specified in the packet header. The TagTTL value is decremented each time the packet propagates through a router cluster node 402, whereas the packet TTL value is decremented 584 only once as part of packet exit processing by the exit router cluster node 402.

[114] The routed and tagged packet is provided to a switch block 576. The switch block 576, based on the tag information and perhaps header information, queues the routed packet in an internal output port queue 548 or the self queue 550. A packet conveying content will typically be queued in one of the internal

output port queues 548 of the router cluster node 402, while packet encapsulated signaling and control messages may be queued in the self queue 550 to implement content transport control functionality.

[115] Various other routing functions may be provided including, but not limited to, address resolution processing. As packets are exemplary transmitted employing the Internet Protocol (IP), an in-band Address Resolution Protocol (ARP) is employed to access address resolution services provided in a typical IP communication network. The processing of ARP packets is schematically shown in FIG. 5B. Without limiting the invention to the particular implementation shown, a classifier block classifies packets by type: IP packets are provided to classifier block 564, ARP responses are provided to an ARP responder block, ARP queries and packets processed by the ARP responder are switched by block 576 to respective output-port-associated ARP querier blocks. ARP functionality may also be implemented out-of-band via the management node 410.

[116] Other routing (related) functionality such as, but not limited to: Reverse ARP (RARP), Border Gateway Protocol (BGP), etc. may be implemented in accordance with the exemplary embodiment by specifying a appropriate packet flows in the router-cluster-node-centric configuration.

[117] FIG. 5C shows router-cluster-node-centric configuration details related to processing packets received via an internal port 556, the logical loopback port 554, or from the operating system 558. Such packets may either require special functionality, transit, or exit processing.

[118] A classifier 560 classifies received packets in accordance with information specified in the tag and perhaps also held in the packet header.

[119] If the tag specifies that the received packet requires special processing, such as but not limited to: encryption/decryption, video stream processing (combine, decode, encode, format translation, etc.), authentication, directory

services, etc., the classifier 560 determines from the tag information and destination information in the packet header and tag whether the special functionality is provided by the cluster router node 402(/406) itself or by a special purpose node 406 associated with an cluster-remote management node 410. The packet is provided to the OS, block 508, or to the management node 410 via block 512 as determined. The classifier 560 may determine that special processing may be provided by the subject router cluster node 402(/406) based on the type of special processing required as specified in the tag.

[120] Decision block 580 determines whether the subject router cluster node 402 is the exit router cluster node specified in the tag of a received packet.

[121] If the router cluster node 402 is not the exit router cluster node, the packet is in transit. Decision block 578 determines whether the TagTTL value is zero. If the TagTTL value is zero, the packet is discarded thus preventing packets from propagating in the cluster router lattice indefinitely. If the TagTTL value is not too low, the TagTTL value is decremented by block 574 and the packet is provided to the switch block 576 for forwarding.

[122] If the subject router cluster node 402 is the exit router cluster node, as part of exit packet processing, the tag is removed by functional block 582, and the packet TTL is decremented by functional block 584. Not all received packets may be tagged such as low TTL packets. The configuration is exemplary of the flexibility provided.

[123] A packet fragmenter block 586 fragments packets in accordance with transport characteristics of the external transport links beyond the router cluster node 402 and therefore beyond the cluster router 400.

[124] A classifier block 588 classifies the packet in accordance with the packet's priority and the packet is stored in an appropriate priority queue 590.

[125] A scheduler block 592, in accordance with a queue service discipline enforcing quality of service guarantees, provides packets from the priority

queues 590 to a switch block 594 which takes into account the network address of the next hop communications network node held in the packet header of each packet provided, to determine the appropriate external output port 530 to forward the packet therethrough. The packet is queued for transmission in an external output port queue 528.

[126] Making reference to FIG. 5B, the router cluster node may also receive a packet from the management port 598 which is forwarded to the OS 508. Packets received via the management port 598 include packets sent for special processing to a cluster-remote management node 410, or to a special purpose router cluster node 406 associated with the management node 410.

[127] The OS takes the necessary steps to return 558 (FIG. 5C) all packets which have completed special processing to be further processed in accordance with the router-cluster-node-centric specification.

[128] As mentioned above, the separation between internal and external ports is not necessary. FIG. 6 shows schematically a router-cluster-node-centric configuration 600, corresponding to the router-cluster-node-centric configuration 500 presented in FIG. 5 B and C, with packet processing flow specifications rerouted based on all ports being equivalent. All packets are provided to a decision block 602 determining whether a received packet is tagged or not.

[129] The router cluster nodes 402 need not have the same processing capacity nor be supplied by the same equipment vendor, although use of same vendor equipment would reduce maintenance overheads typically associated with stocking replacement parts.

[130] However, in providing improved packet processing capabilities, specialized PC platforms may be used for performing specialized packet processing. For example, as mentioned above, a packet payload encryption/decryption packet processing response may be necessary.

Encryption/decryption algorithms may make use of specialized CPU processing functionality to speed up packet payload encryption/decryption. A difference exists between employing Complex Instruction Set Computing (CISC) platforms as opposed to Reduced Instruction Set Computing (RISC) platforms. Both CISC and RISC router cluster nodes 402(/406) may however run the same operating system, Linux, and the exemplary router framework specially compiled for each specialized PC platform. Therefore the router-cluster-node-centric configuration in terms of routing functionality blocks may be distributed to the all router cluster nodes 402(/406) regardless of the hardware implementation thereof.

[131] Therefore a low-cost, scalable cluster router design re-configurable in a simple cost conscious manner is provided. The routing functionality of the cluster router can easily be re-configured via modifying existing or employing additional special purpose routing functionality blocks to support varying customer needs, and different functional requirements. The routing functionality supported by and the configuration of the cluster router may also be made dependent on where the cluster router 400 is deployed in a communications network (edge/core/access).

[132] A low-cost, scalable cluster router is useful as a communications network edge, where cost and scalability are very important. Such a cluster router could also be useful in small enterprise networks for the same reason. The cluster router design further provides a useful research tool due to its high degree of flexibility.

[133] In accordance with the exemplary embodiment of the invention, an operator is provided with the ability to partition the computing power of a cluster router 400 into distinct virtual machines to provide engineered packet processing in respect of specific packet processing functionality via the router-cluster-node-centric configuration. Packet processing is further enhanced by

employing special purpose router cluster nodes 406 having a better specific packet processing functionality to cost ratio.

[134] The embodiments presented are exemplary only and persons skilled in the art would appreciate that variations to the above described embodiments may be made without departing from the spirit of the invention. The scope of the invention is solely defined by the appended claims.

WE CLAIM:

1. A cluster-based router comprising:

   a. a plurality of interconnected router cluster nodes, the routing capacity of the cluster router increasing substantially O(N) with the number N of router cluster nodes in the cluster router, each router cluster node having a group of cluster router external links enabling packet exchange with a plurality of external communication network nodes;

   b. at least one special purpose cluster node providing special packet processing functionality in the cluster router;

   c. a plurality of cluster router internal links interconnecting cluster nodes forming an intra-connection network ensuring a high path diversity in providing resiliency to failures; and

   d. a provisioned router-cluster-node-centric configuration distributed to each router cluster node for operating in accordance therewith in effecting distributed routing of the conveyed packets,

   employing the at least one special purpose router cluster node providing a reduction in the development, validation, deployment and re-configuration of the cluster router.

2. The cluster router claimed in claim 1, wherein the router-cluster-node-centric configuration further comprises routing functional blocks and specifies packet processing flows between the routing functional blocks effecting packet processing employing one of: a single router cluster node, and a group of cluster nodes.

3. The cluster router claimed in claim 1, wherein each router cluster node further comprises a personal computer platform providing flexibility and cost savings in the development, deployment, maintenance, and expandability of the cluster router.

4. The cluster router claimed in claim 1, wherein at least one special purpose cluster node providing special packet processing functionality further comprises one of: a specially coded personal computer platform, a personal computer platform having designed hardware characteristics in providing specific functionality, dedicated hardware implemented equipment designed to provide an enhancement in providing special packet processing functionality, and a router cluster node further coded to provide special packet processing functionality.

5. The cluster router claimed in claim 1, wherein the intra-connection network further comprises an n dimensional toroidal topology, wherein 2*n internal links interconnect each router cluster node with 2*n adjacent neighboring router cluster nodes; the routing capacity of the cluster router being increased substantially linearly by adding an n-1 dimensional slice of router cluster nodes to the cluster router.

6. The cluster router claimed in claim 5, wherein the intra-connection network comprises a three dimensional toroidal topology, wherein six internal links interconnect each router cluster node with six adjacent neighboring router cluster nodes.

7. The cluster router claimed in claim 1, wherein the intra-connection network further comprises one of unidirectional and bi-directional internal interconnecting links.

8. The cluster router claimed in claim 1, further comprising: a router cluster node designated as a management node, should a management node designated router cluster node fail, another router cluster node being designated as a management node without making changes to the cluster router infrastructure.

9. The cluster router claimed in claim 1, further comprising: a router cluster node designated as a special purpose cluster node, should a special purpose cluster node designated router cluster node fail, another router cluster node being designated as a special purpose cluster node without making changes to the cluster router infrastructure.

10. The cluster router claimed in claim 1, further comprising:

    a. at least one management node; and

    b. a plurality of management links interconnecting the at least one management node with the plurality of router cluster nodes and enabling one of out-of-band: configuration deployment to each router cluster node, router cluster node initialization, and reporting functionality,

    employing the plurality of management links reducing an in-band cluster router management overhead.

11. The cluster router claimed in claim 10, wherein the plurality of management links from one of a star and a bus topology.

12. The cluster router claimed in claim 11, wherein the at least one special purpose cluster node is associated with the management node, special functionality being available one-hop-away from each router cluster node.

13. The cluster router claimed in claim 1, further comprising an cluster router internal addressing process dynamically determining router cluster node addressing.

14. The cluster router claimed in claim 1, further comprising a cluster router external addressing process dynamically determining a cluster router address.

15. The cluster router claimed in claim 1, further comprising means for distributing to each router cluster node information regarding availability and addressing information regarding special purpose cluster nodes.

16. The cluster router claimed in claim 15, further employing methods of detecting special purpose cluster nodes providing special packet processing functionality.

17. A router cluster node of a plurality of router cluster nodes interconnected in a cluster router, the router cluster node comprising:

    a. a plurality of cluster router internal interconnecting links connected thereto, the internal interconnecting links enabling the exchange of packets with adjacent cluster nodes in the cluster router;

    b. at least one cluster router external link connected thereto, the at least one external link enabling exchange of packets between external communications network nodes and the cluster router; and

    c. a router-cluster-node-centric configuration to effect distributed routing of the conveyed packets,

    the equivalency between router cluster nodes in the cluster router providing a scalable router.

18. The router cluster node claimed in claim 17, wherein the router-cluster-node-centric configuration further comprises routing functional blocks and specifies packet processing flows between the routing functional blocks effecting packet routing employing one of: a single router cluster node, and a group of router cluster nodes.

19. The router cluster node claimed in claim 18, wherein the router-cluster-node-centric configuration further comprises routing functional blocks determining a need for special packet processing and specifies packet processing flows forwarding packets to at least one special purpose cluster node associated with the router cluster.

20. The router cluster node claimed in claim 17, wherein each router cluster node comprises a personal computer platform providing flexibility and cost savings in the development, deployment, maintenance, and expandability of the cluster router.

21. The router cluster node claimed in claim 17, wherein 2*n cluster router internal links interconnect the router cluster node with 2*n adjacent neighboring router cluster nodes in accordance with an n dimensional toroidal topology, the routing capacity of the cluster router being increased substantially linearly by adding an n-1 dimensional slice of router cluster nodes to the cluster router.

22. The router cluster node claimed in claim 17, further comprising: a management link interconnecting the router cluster node to a management node.

23. The router cluster node claimed in claim 17, further providing management functionality.

24. The router cluster node claimed in claim 17, further providing special packet processing functionality as a special purpose cluster node.

25. The router cluster node claimed in claim 24, wherein the special purpose cluster node provides packet processing in respect one of: authentication, decryption, encryption, decoding, encoding, billing, directory access, and video stream processing.

26. A router-cluster-node-centric configuration enabling the provision of a distributed packet routing response in a cluster router having a plurality of router cluster nodes, the configuration comprising:

    a. a plurality of routing functional blocks; and

    b. at least one router-cluster-node-centric packet processing flow, via the plurality of routing functional blocks, to effect routing of packets received at the cluster router employing one of a single router cluster node and a group of router cluster nodes.

27. The router-cluster-node-centric configuration claimed in claim 26, further comprising:

    a. an entry-and-routing processing packet processing flow specification;

    b. a transit packet processing flow specification; and

    c. an exit packet processing packet processing flow specification,

    the packet processing flow specifications enabling a received packet to undergo entry and routing processing at an entry router cluster node, optionally transit via at least one intermediary router cluster node, and undergo exit processing at an exit router cluster node.

28. The router-cluster-node-centric configuration claimed in claim 26, wherein the router cluster node configuration further employs a tag conveyed with each packet within the cluster router infrastructure, the tag holding specifiers for tracking packet processing within the cluster router.

29. The router-cluster-node-centric configuration claimed in claim 28, wherein each tag identifies an associated packet as one having received a routing response and propagating through the cluster router towards a specified exit router cluster node.

30. The router-cluster-node-centric configuration claimed in claim 28, wherein each tag identifies an associated packet as one requiring special processing and propagating through the cluster router towards one of: a special purpose cluster node, and the router cluster node which determined that the packet required special processing.

31. The router-cluster-node-centric configuration claimed in claim 28, wherein each tag comprises a combination of: an optional packet header, a packet trailer, and an additional header encapsulating the associated packet having cluster router relevance only.

32. The router-cluster-node-centric configuration claimed in claim 28, wherein each tag holds a tag time-to-live specification decremented while the associated packet propagates via router cluster nodes in the cluster, the packet being discarded when the time-to-live specification is zero and the packet has not reached a corresponding exit router cluster node thereby reducing transport overheads.

33. A router-cluster-node-centric configuration enabling the provision of a distributed packet routing response in a cluster router having a plurality of router cluster nodes and at least one special purpose cluster node as claimed in claim 26, the configuration further comprising:

a. at least one routing functional block determining a need for special functionality in respect of processing a packet; and

b. at least one router-cluster-node-centric packet processing flow effecting forwarding of the packet to a special purpose cluster node for processing.

34. The router-cluster-node-centric configuration claimed in claim 33, wherein the at least one router-cluster-node-centric packet processing flow further specifies one of: storing a copy of the packet header and a corresponding tag in an optional header of the packet; and storing information about the packet in a storage structure for the purposes of continuing packet processing in accordance with the router-cluster-node-centric configuration.

35. The router-cluster-node-centric configuration claimed in claim 33, wherein the at least one cluster-node-centric packet processing flow further specifies at least one packet processing flow for further processing a packet having undergone packet processing at a special purpose cluster node.

36. The router-cluster-node-centric configuration claimed in claim 33, wherein the at least one cluster-node-centric packet processing flow further specifies employing addressing information stored in the packet header in forwarding the packet requiring special processing towards a special purpose cluster node.

Abstract

A cluster router architecture and methods for performing distributed routing are presented. The cluster router architecture includes off-the shelf Personal Computer (PC) hardware-based router cluster nodes interconnected in an intra-connection network in multiple dimensions. Each PC-based router cluster node is provided with the same routing functionality and a router-cluster-node-centric configuration enabling each router cluster node by itself or multiple router cluster nodes in the cluster router to provide routing responses for packets pending processing. Optimized packet processing in respect of specific functionality is provided via special purpose router cluster nodes not necessarily PC-based taking part as cluster nodes in the cluster router lattice. The method divides packet processing into entry packet processing and routing response processing; special processing; and exit processing. Entry packet processing and routing response processing is performed by router cluster nodes receiving packets from communication networks in which the cluster router participates. Exit packet processing is performed by router cluster nodes transmitting packets into communication networks in which the cluster router participates. Packet processing in accordance with the router-cluster-node-centric specification is interrupted on determining that special processing is required in respect of a packet, and the packet is handed over to a corresponding special purpose router cluster node. Advantages are derived from: a configurable, and scalable cluster router design providing a re-configurable high routing capacity using cost effective stock PC hardware; from the intra-connection network which provides a high degree of diversity ensuring resilience to equipment failure; from the use of a star topology with respect to management links which reduces management overheads in the intra-connection network; and from the ability to forward packets to designated special purpose router cluster nodes optimized to provide specific packet processing functionality.

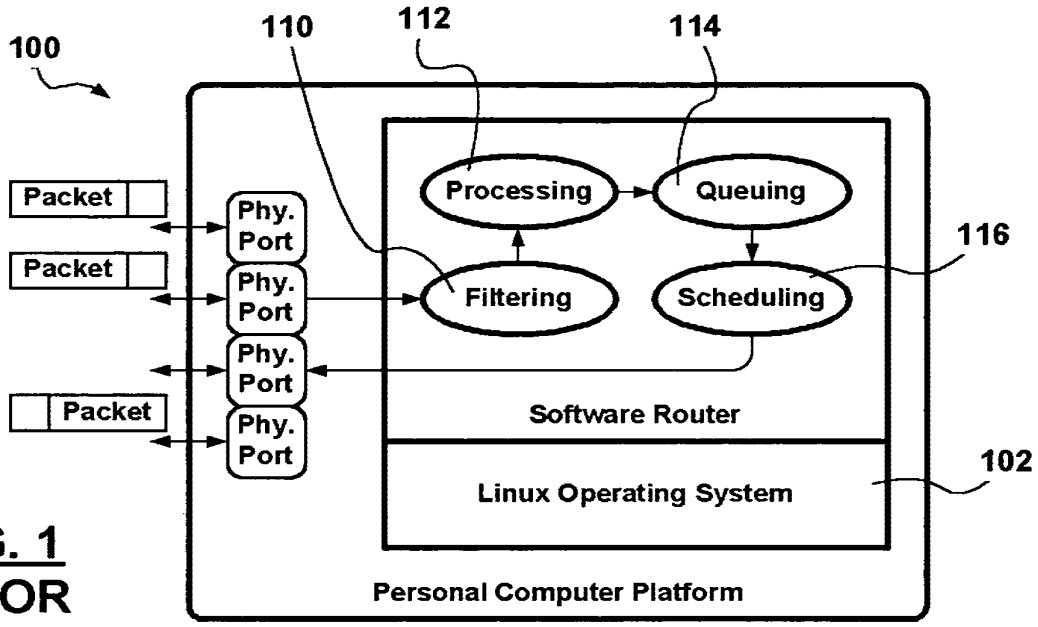


FIG. 1
PRIOR ART

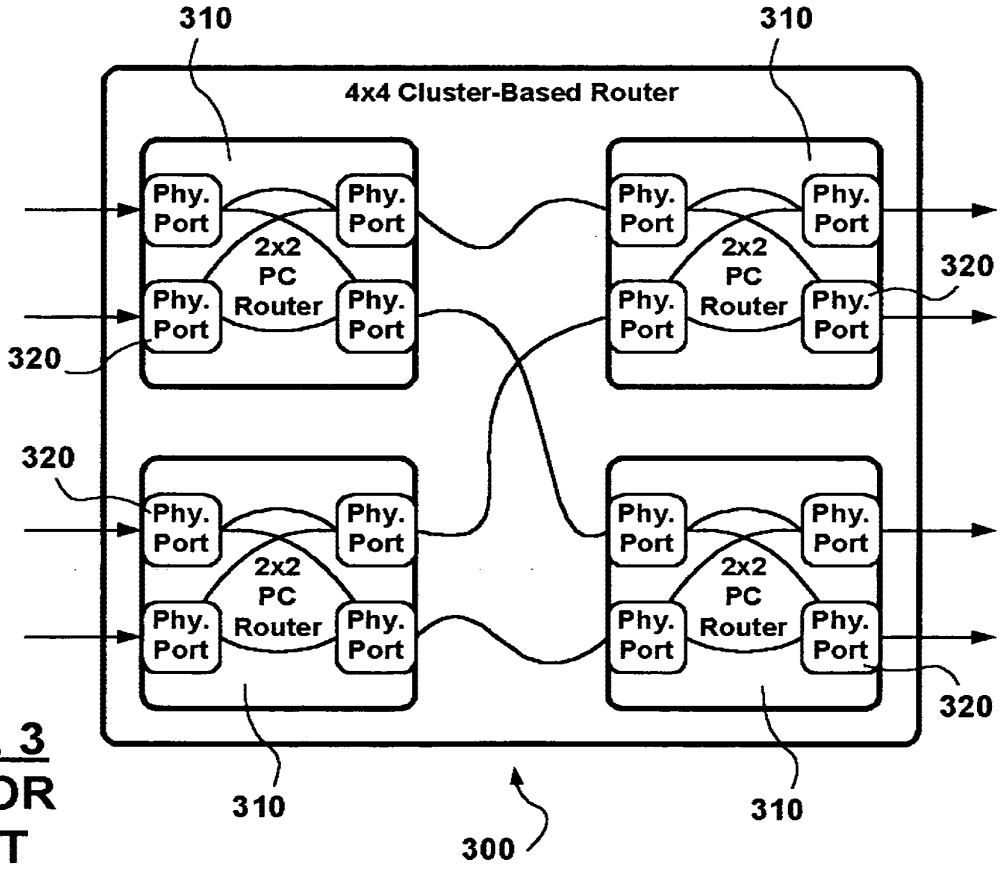


FIG. 3
PRIOR ART

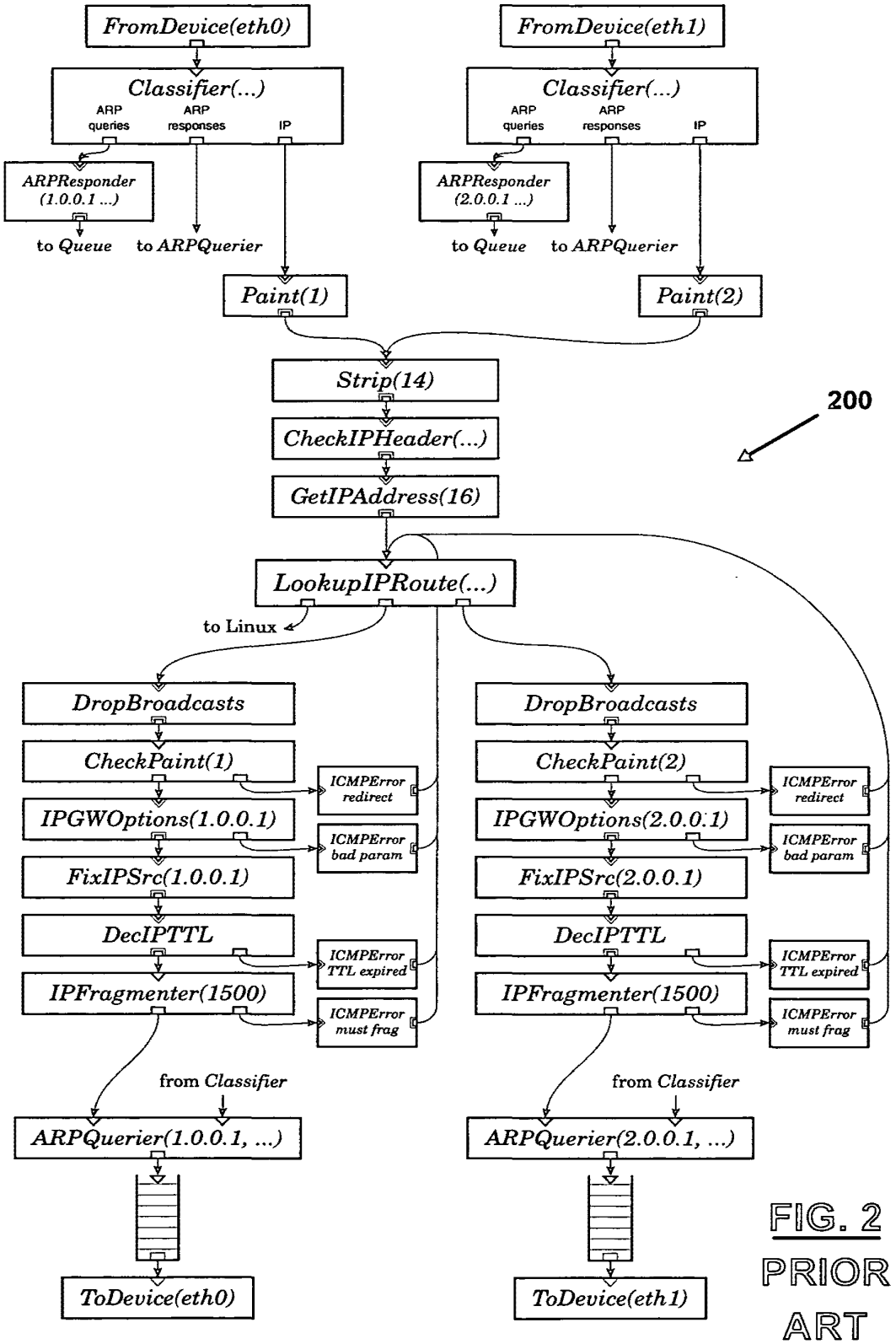


FIG. 2
PRIOR ART

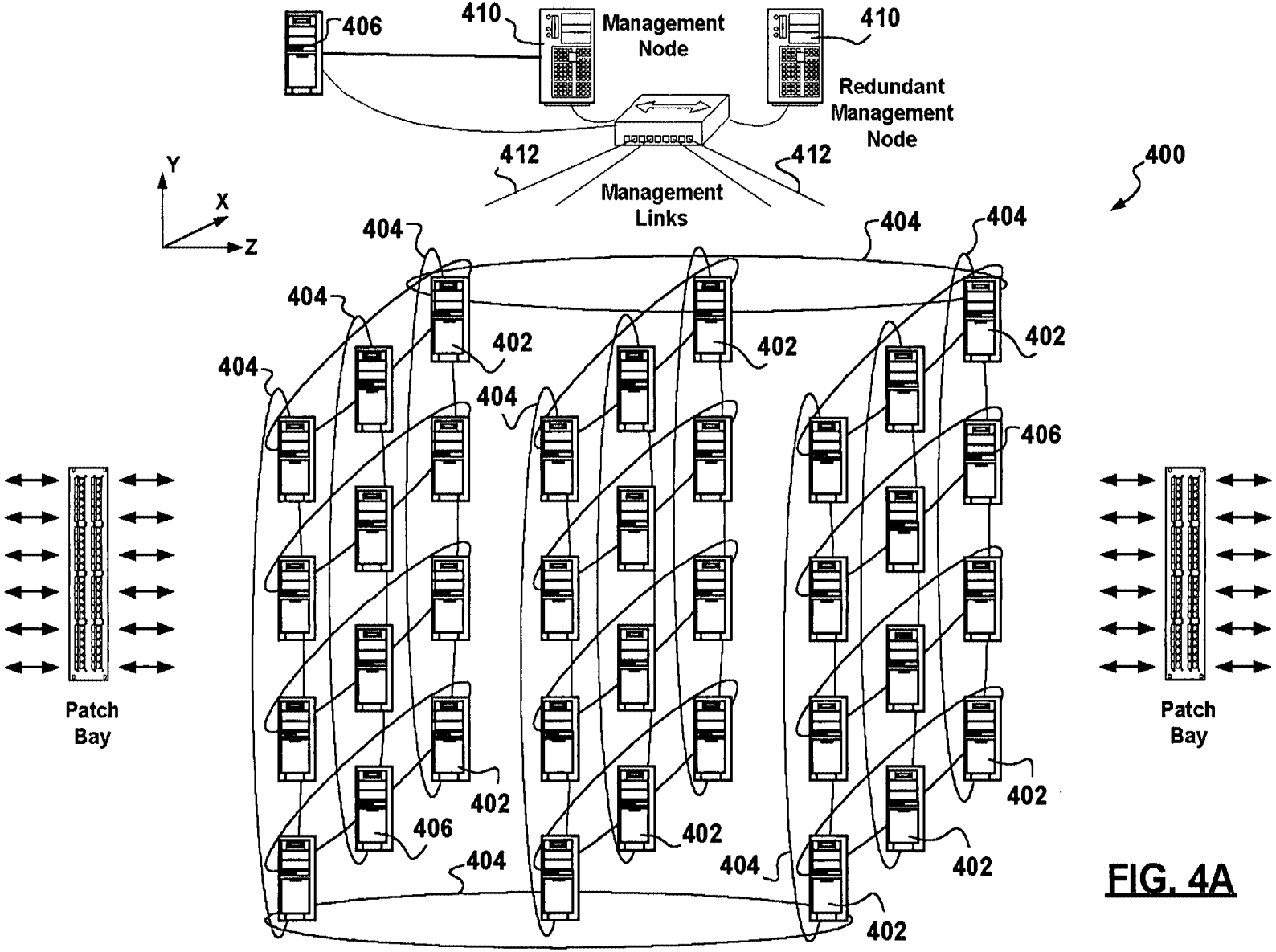

406
410
Management Node
410
Redundant Management Node
412
412
Management Links
400
Y
X
Z
404
402
406
Patch Bay
Patch Bay

FIG. 4A

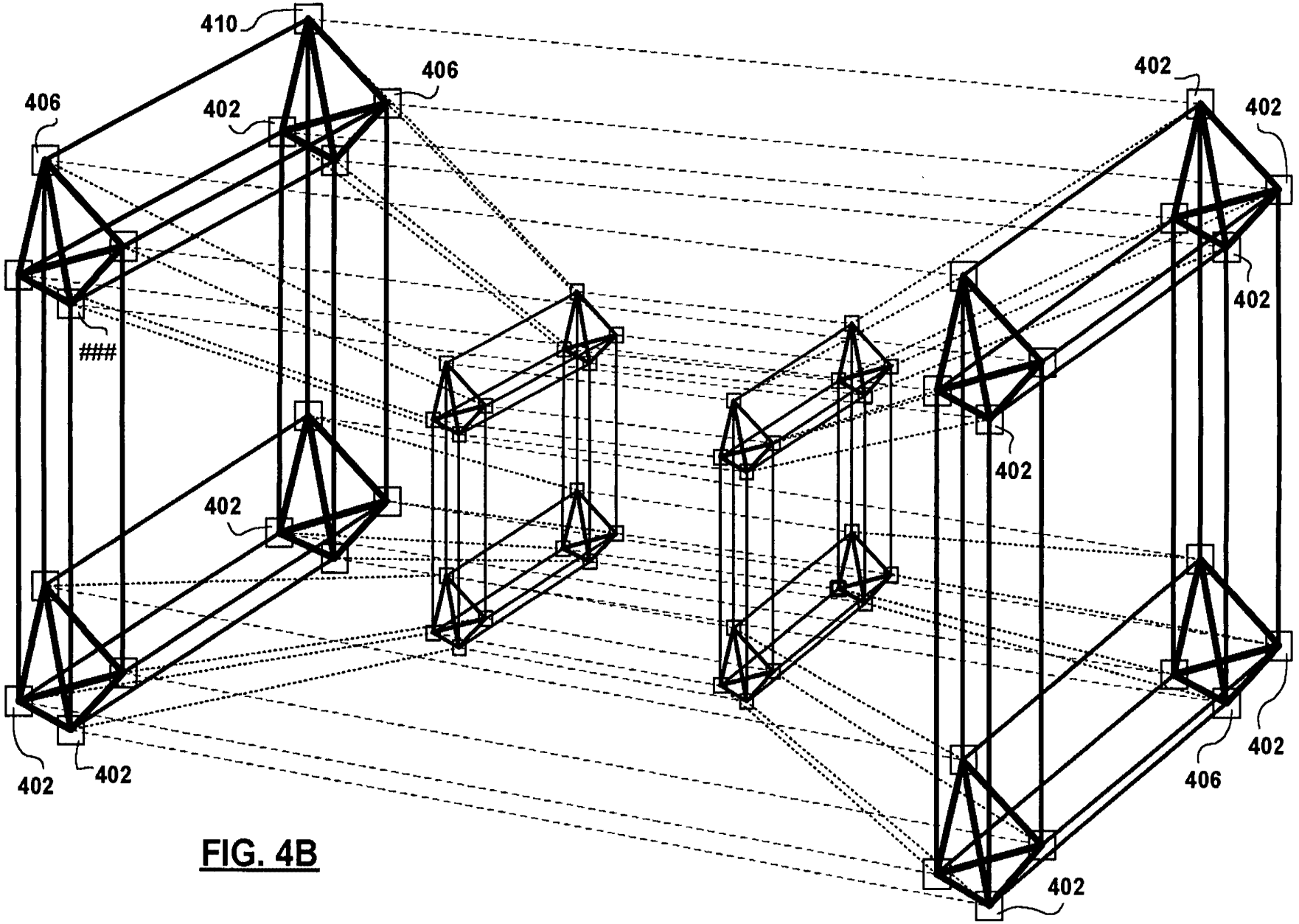


FIG. 4B

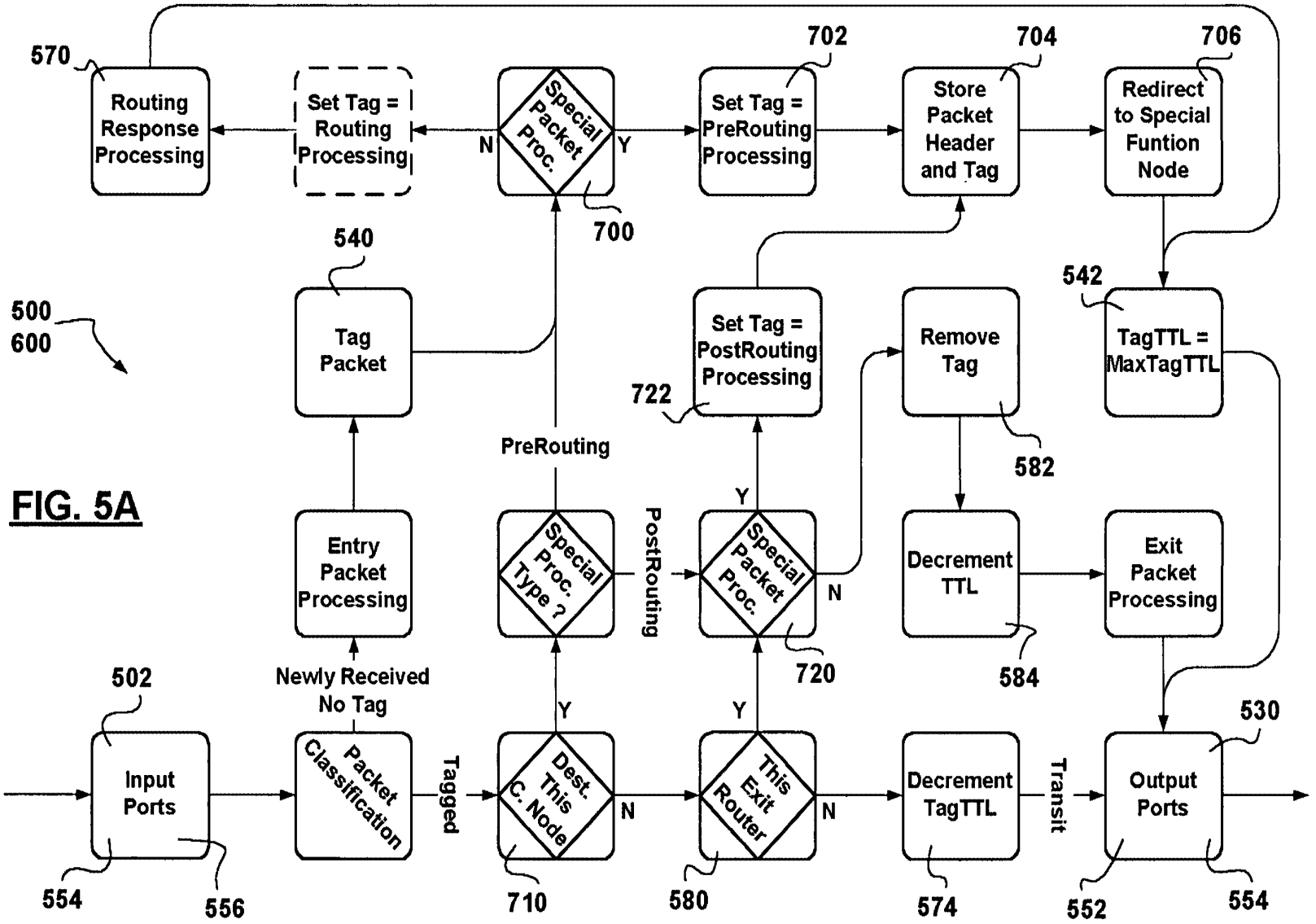

570
Routing Response Processing
Set Tag = Routing Processing
Special Packet Proc.
N
Y
700
702
Set Tag = PreRouting Processing
704
Store Packet Header and Tag
706
Redirect to Special Funtion Node
542
TagTTL = MaxTagTTL
500
600
540
Tag Packet
PreRouting
722
Set Tag = PostRouting Processing
Remove Tag
582
Entry Packet Processing
Special Proc. Type ?
PostRouting
Special Packet Proc.
720
Decrement TTL
584
Exit Packet Processing
502
Input Ports
554
556
Newly Received No Tag
Packet Classification
Tagged
Y
Dest. This C. Node
710
This Exit Router
580
Decrement TagTTL
574
Transit
530
Output Ports
552
554

FIG. 5A

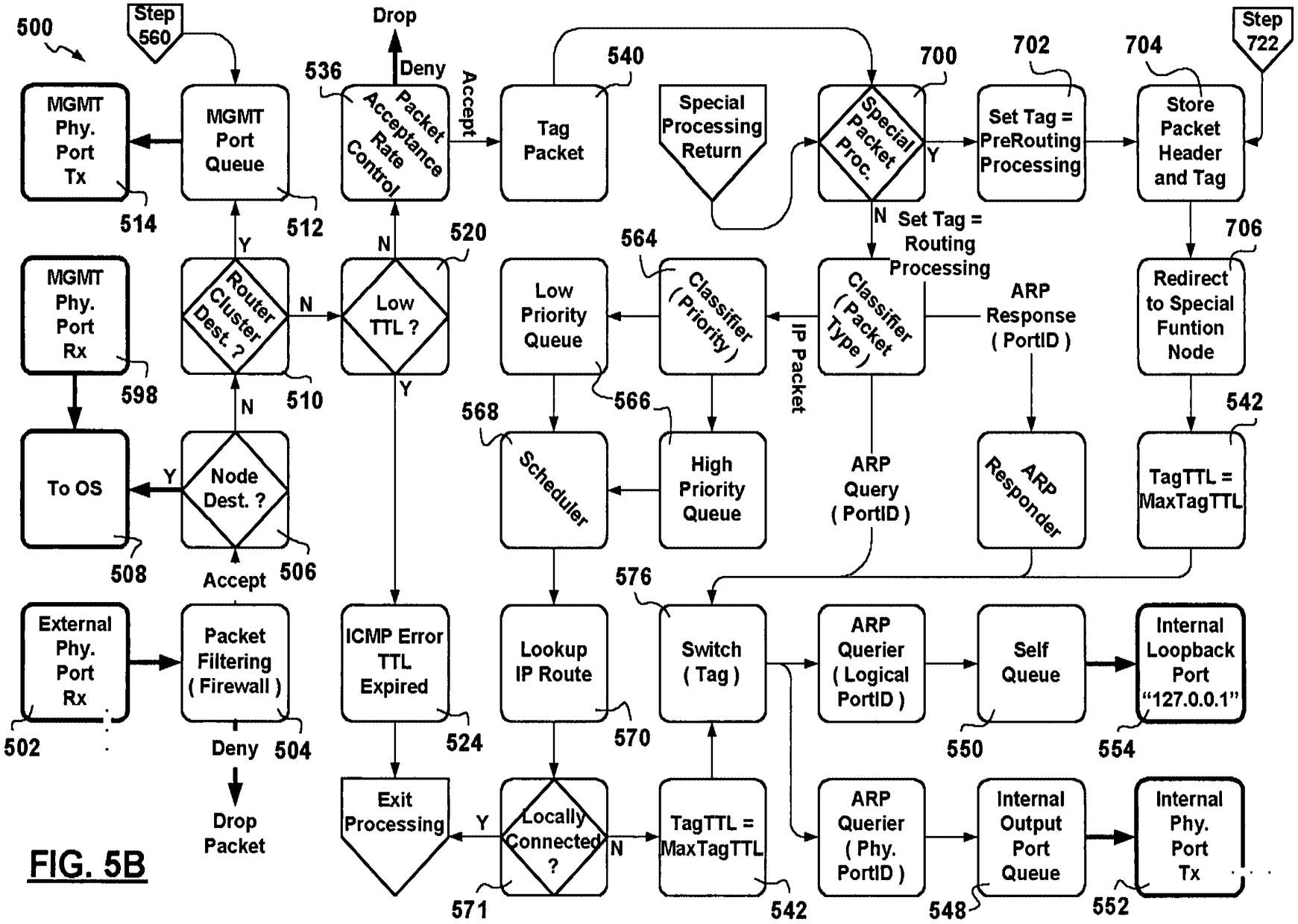
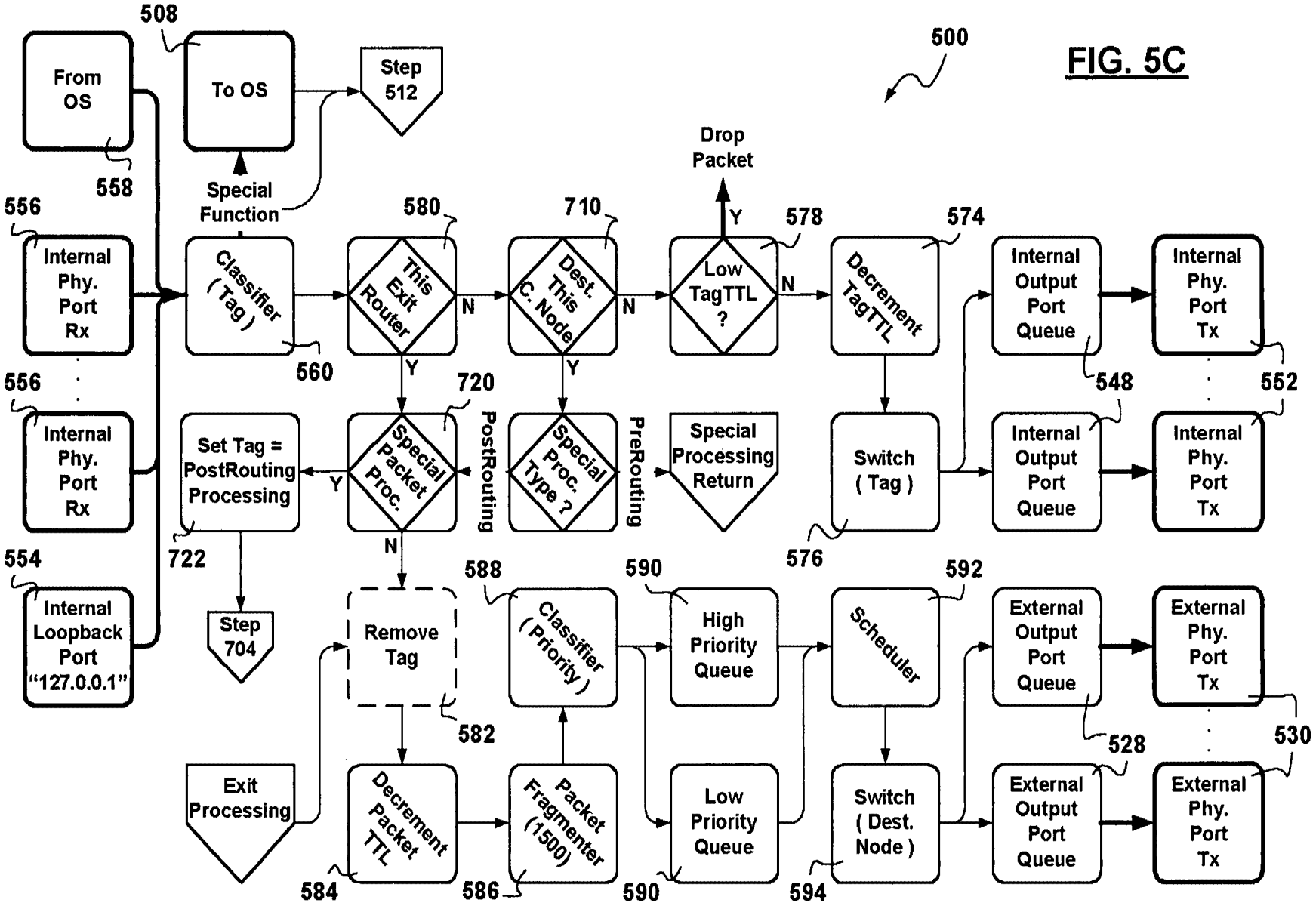

500
Step 560
MGMT Phy. Port Tx
514
MGMT Port Queue
512
Drop
Deny
536
Packet Acceptance Rate Control
Accept
Tag Packet
540
Special Processing Return
700
Special Packet Proc.
Y
N
Set Tag = PreRouting Processing
702
Store Packet Header and Tag
704
Step 722
706
Set Tag = Routing Processing
MGMT Phy. Port Rx
598
Router Cluster Dest. ?
Y
N
510
Low TTL ?
520
564
Classifier (Priority)
Classifier (Packet Type)
IP Packet
ARP Response (PortID)
Redirect to Special Funtion Node
Low Priority Queue
566
568
542
To OS
508
Node Dest. ?
Accept
506
Scheduler
High Priority Queue
ARP Query (PortID)
ARP Responder
TagTTL = MaxTagTTL
576
External Phy. Port Rx
502
Packet Filtering (Firewall)
Deny
504
Drop Packet
ICMP Error TTL Expired
524
Lookup IP Route
570
Switch (Tag)
ARP Querier (Logical PortID)
Self Queue
550
Internal Loopback Port "127.0.0.1"
554
Exit Processing
Locally Connected ?
571
TagTTL = MaxTagTTL
542
ARP Querier (Phy. PortID)
Internal Output Port Queue
548
Internal Phy. Port Tx
552

FIG. 5B


500
FIG. 5C
508
From OS
To OS
Step 512
Special Function
558
556
Internal Phy. Port Rx
Classifier (Tag)
560
580
This Exit Router
N
Y
710
Dest. This C. Node
N
Y
Drop Packet
Y
578
Low TagTTL ?
N
574
Decrement TagTTL
Internal Output Port Queue
Internal Phy. Port Tx
548
552
556
Internal Phy. Port Rx
720
Special Packet Proc.
Y
N
PostRouting
Special Proc. Type ?
PreRouting
Special Processing Return
Switch (Tag)
Internal Output Port Queue
Internal Phy. Port Tx
Set Tag = PostRouting Processing
722
576
554
Internal Loopback Port "127.0.0.1"
Step 704
588
Classifier (Priority)
590
High Priority Queue
592
Scheduler
External Output Port Queue
External Phy. Port Tx
Remove Tag
582
528
530
Exit Processing
Decrement Packet TTL
584
Packet Fragmenter (1500)
586
Low Priority Queue
590
Switch (Dest. Node)
594
External Output Port Queue
External Phy. Port Tx

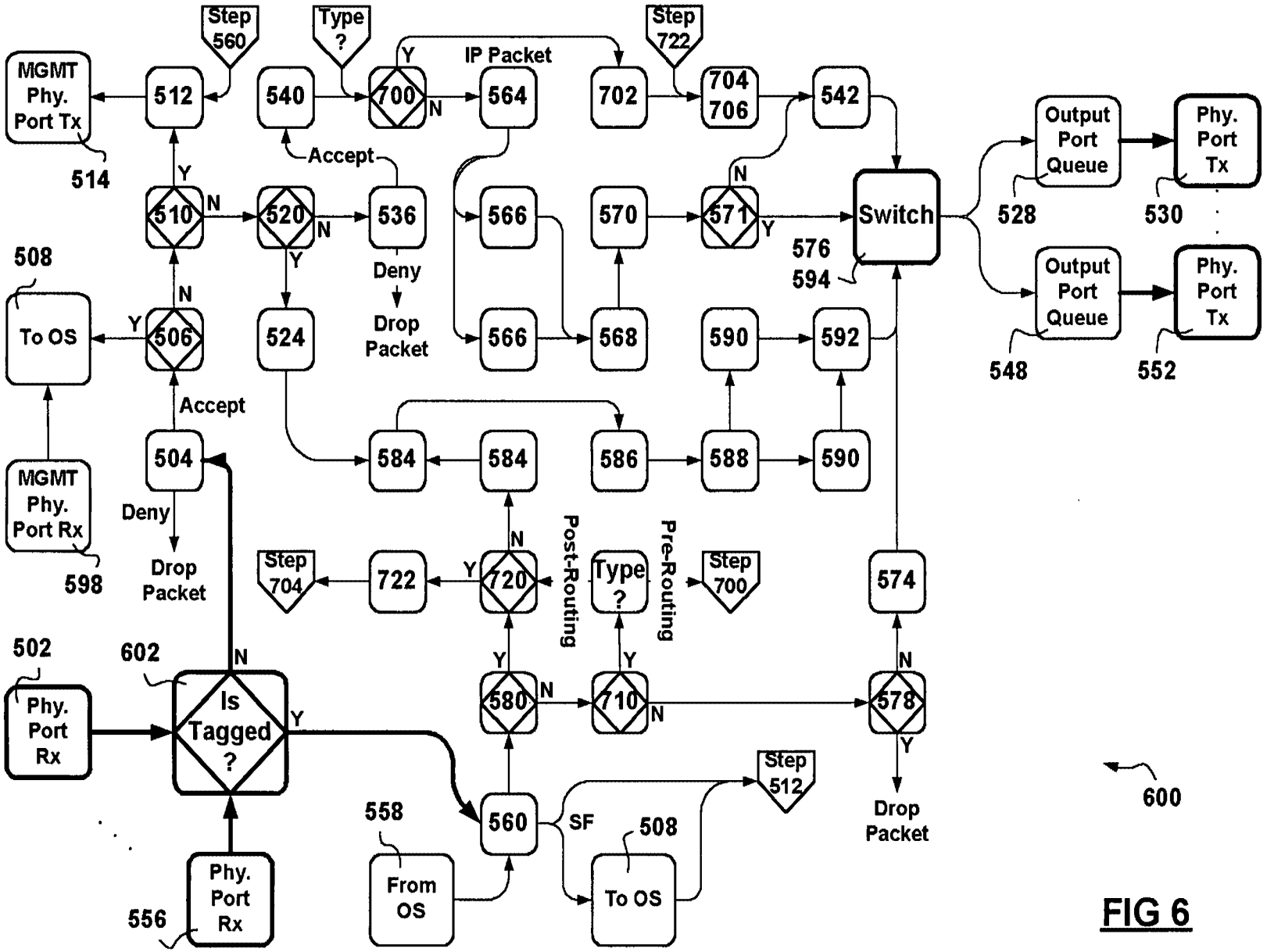

Step 560
Type ?
IP Packet
Step 722
MGMT Phy. Port Tx
512
540
700
564
702
704 706
542
514
Accept
Output Port Queue
Phy. Port Tx
528
530
510
520
536
566
570
571
Switch
576
594
508
Deny
To OS
506
524
Drop Packet
566
568
590
592
Accept
548
552
504
584
584
586
588
590
MGMT Phy. Port Rx
Deny
598
Drop Packet
Step 704
722
720
Type ?
Step 700
574
Post-Routing
Pre-Routing
502
602
Phy. Port Rx
Is Tagged ?
580
710
578
Step 512
Drop Packet
600
558
560
SF
508
From OS
To OS
Phy. Port Rx
556

FIG 6

DECLARATION AND POWER OF ATTORNEY FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63) ☒ Declaration Submitted with Initial Filing. ☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16(e)) required).	Attorney Docket No.: 137744-US First Named Inventor: Peter Rabinovitch COMPLETE IF KNOWN Application Number: Filing Date: Group Art Unit: Examiner Name:

As a below named inventor, I hereby declare that:

My residence, mailing address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

SOFTWARE CONFIGURABLE CLUSTER-BASED ROUTER USING HETEROGENEOUS NODES AS CLUSTER NODES

the specification of which
☒ is attached hereto.
☐ was filed on _____ as United States Application Serial No. _____ or PCT International Application No. _____ and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

Foreign Application(s) and/or Claim of Foreign Priority
I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or any PCT international application having a filing date before that of the application on which priority is claimed.

Country	Application Number	Date Filed	Priority Claimed Under 35 U.S.C. §119
			☐ Yes ☐ No
			☐ Yes ☐ No

Provisional Application
I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below:

Application Serial Number	Filing Date

U.S. Priority Claim
I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

Applicati n Serial Number	Filing Date	Status - Patented/Pending/Abandoned

POWER OF ATTORNEY

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: John Granchelli Registration No. 39,512
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor: **Peter Rabinovitch**

Sole or first inventor's signature: _____ Date: 12-Nov-2003
Residence: City **Kanata** State **Ontario, Canada** Citizenship: **Canadian**
Mailing Address: **1386 Halton Terrace, Kanata, Ontario, K2K 2R1, Canada**

Full name of second inventor, if any:

Second inventor's signature: _____ Date: _____
Residence: City _____ State _____ Citizenship: _____
Mailing Address: _____

Full name of third inventor, if any:

Third inventor's signature: _____ Date: _____
Residence: City _____ State _____ Citizenship: _____
Mailing Address: _____

Full name of fourth inventor, if any:

Fourth inventor's signature: _____ Date: _____
Residence: City _____ State _____ Citizenship: _____
Mailing Address: _____

Full name of fifth inventor, if any:

Fifth inventor's signature: _____ Date: _____
Residence: City _____ State _____ Citizenship: _____
Mailing Address: _____

Full name of sixth inventor, if any:

Sixth inventor's signature: _____ Date: _____
Residence: City _____ State _____ Citizenship: _____
Mailing Address: _____

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re. Application of: Peter Rabinovitch
Serial No.:
Filed:
Title: SOFTWARE CONFIGURABLE CLUSTER-BASED ROUTER USING HETEROGENEOUS NODES AS CLUSTER NODES

Atty. Docket No.: 137744-US

The Commissioner of Patents and Trademarks
Washington, D.C. 20231
U.S.A.

ASSOCIATE POWER OF ATTORNEY

Dear Sir:

The undersigned, John Granchelli (Reg. No. 39,512), is an agent of record for the captioned U.S. Patent Application under a Power of Attorney filed with the U.S. Patent Office contemporaneously herewith.

Pursuant to 37 CFR Section 1.34(b), the undersigned hereby appoints the following registered practitioner as associate agent of record:

Jim Zegeer, Esq.
Registration No. 18,957

to prosecute said application and to transact all business in the U.S. Patent and Trademark Office connected therewith. The appointment of the above practitioners does not affect, and is not intended to affect, the status of any other practitioner who has been appointed previously as agent of record for this matter.

Please direct any and all correspondence and telephone calls to:

Jim Zegeer, Esq.
Law Office of Jim Zegeer
801 North Pitt Street, #108
Alexandria, VA 22314
Telephone: 703-684-8333
Facsimile: 703-549-8411

Respectfully submitted,

Nov 12/03
Date

John Granchelli
Reg. No. 39,512

Alcatel Canada Inc.
600 March Road
Ottawa, ON K2K 2E6
CANADA
Telephone: 613-784-6523
Facsimile: 613-784-8923

PATENT APPLICATION SERIAL NO. _____

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

11/18/2003 RHARIS1 00000080 10712104

01 FC:1001 770.00 OP
02 FC:1202 288.00 OP

PTO-1556
(5/87)

*U.S. Government Printing Office: 2002 — 489-267/69033

PATENT APPLICATION FEE DETERMINATION RECORD
Effective October 1, 2003

Application or Docket Number: 10712104

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)
TOTAL CLAIMS	36	
FOR	NUMBER FILED	NUMBER EXTRA
TOTAL CHARGEABLE CLAIMS	36 minus 20=	* 16
INDEPENDENT CLAIMS	3 minus 3 =	* 0
MULTIPLE DEPENDENT CLAIM PRESENT		☐

* If the difference in column 1 is less than zero, enter "0" in column 2

SMALL ENTITY TYPE ☐		OR	OTHER THAN SMALL ENTITY	
RATE	FEE		RATE	FEE
BASIC FEE	385.00	OR	BASIC FEE	770.00
X$ 9=		OR	X$18=	288
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL		OR	TOTAL	1058

CLAIMS AS AMENDED - PART II

AMENDMENT A	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT B	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20."
***If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3."
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

FORM PTO-875 (Rev. 10/03) Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE